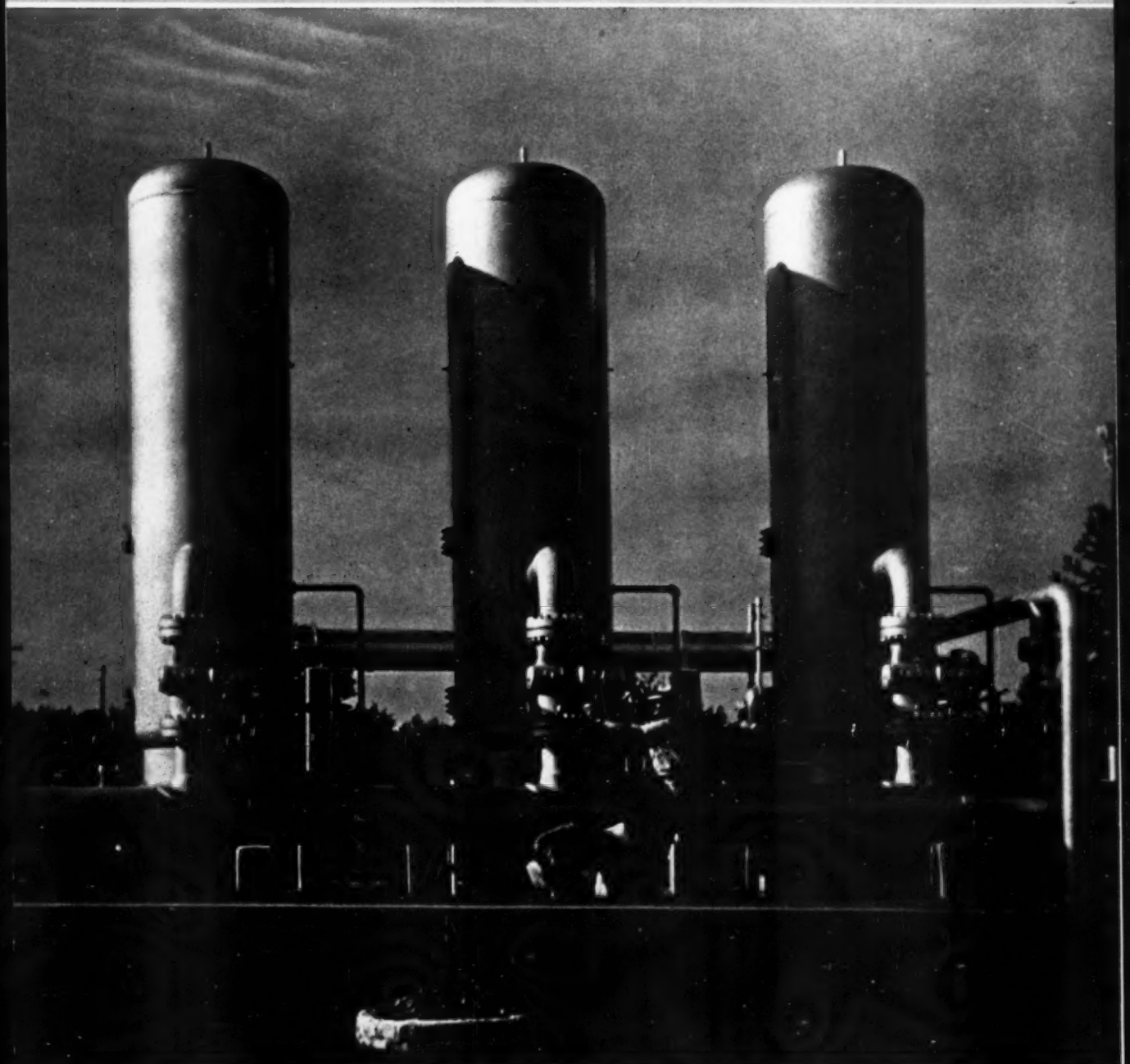
INDUSTRY AND POWER

For Executives and Engineers Responsible For Engineered Plant Services



JANUARY 1953

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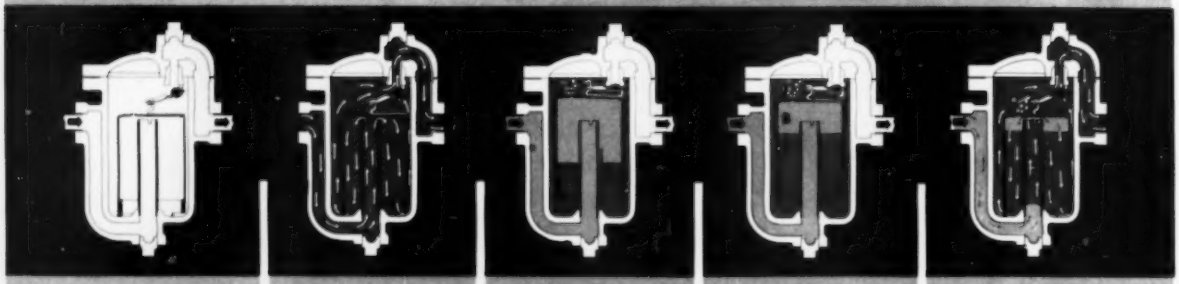
ARMSTRONG TRAPS are Designed to give Outstanding Performance



1. *When trap is installed, inverted bucket is down and valve is wide open.*

2. *When steam is turned on, condensate (solid color) flows into trap and out orifice, until . . .*

SELF-SCRUBBING ACTION (See Fig. 2 above). Note that condensate first flows down between bottom of bucket and trap body, then up and out through orifice. The high velocity flow under bottom of bucket keeps dirt in suspension, washes it out when trap opens. No dirt problems with Armstrong design.

3. *. . . steam (light color) reaching the trap floats the inverted bucket and closes the valve.*

BUCKET FLOATS WHEN LESS THAN ⅓ FULL OF STEAM (See Fig. 3 above). The generous margin of safety (dimension A in Fig. 3 above) insures that the bucket will float with trap body partly full of water. A heavier bucket would give more power but it might float and close the valve.

4. *When more condensate enters, bucket loses buoyancy and pulls on valve lever.*

NO AIR BINDING (See Fig. 4 above). Air mixed with steam passes through the bucket vent, collects at top of trap and is discharged ahead of condensate. The large air-handling capacity of Armstrong traps insures top equipment temperatures and faster heat-up.

5. *When weight of bucket times leverage overcomes pressure on valve, trap opens.*

EXCESS POWER FOR OPENING (See Fig. 3 above). Armstrong design provides a generous safety margin. Reducing dimension B in Fig. 4 would increase power of bucket but margin between test opening pressure and operating pressure would be too low to allow for normal wear and pressure fluctuations.

THE highly efficient design of modern Armstrong traps reflects over 40 years' experience in inverted bucket trap manufacture and application.

ARMSTRONG design offers:

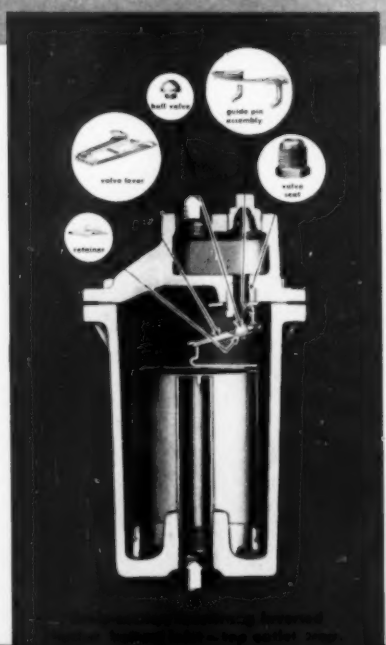
- A "frictionless" leverage system which combines high leverage with wide opening of a large orifice.
- A minimum of parts.
- Strong, corrosion-resistant and wear-resistant materials.
- Generous margins of safety.

FOR TRAP USERS this means:

- Large capacity.
- Dependable service under adverse operating conditions.
- Low maintenance.
- Continuous operation of heating and process equipment.

The soundness of Armstrong design has been proved in thousands of plants all over the world. To insure dependable condensate drainage simply specify: "Traps shall be Armstrong." For additional information, call your local Armstrong Representative or write:

ARMSTRONG MACHINE WORKS
820 Maple Street, Three Rivers, Michigan



● ***SEND FOR*** **NEW 44-PAGE STEAM TRAP BOOK.** Complete data on Armstrong trap design and operation; physical data and list prices; capacities; selection, installation and maintenance recommendations Free on request.

ARMSTRONG STEAM TRAPS

Otter Tail Power Company handles lignite efficiently on Link-Belt conveyor system

Read how LINK-BELT's unequalled experience plus quality equipment pays off in low fuel handling costs

WHEN OTTER TAIL POWER CO. planned their Ortonville (Minn.) station, economics dictated lignite be used as fuel. Recognizing the handling difficulties, they and consultant J. F. Pritchard and Co. agreed Link-Belt's broad fuel handling experience offered the best assurance of an efficient system.

And they were right: The Link-Belt-designed system moves up to 240 tons of lignite per hour. Smooth handling minimizes the dusting that is a problem because of the ease with which lignite disintegrates. Clinging or freezing to conveyor belts—and consequent belt misalignment—is solved by using snub and bend pulleys of open slat construction.

You will find it pays to rely on Link-Belt for every detail of your coal handling system—from planning to erection, if desired. Link-Belt builds a complete, quality line for every step in handling coal—from railroad car or ship to bunker. For full information, call the Link-Belt office near you. An experienced engineer will be glad to work with you and your consultants—help you plan for highest efficiency.

LINK-BELT

COAL HANDLING EQUIPMENT

LINK-BELT COMPANY: Plants: Chicago, Indianapolis, Philadelphia, Colmar, Pa., Atlanta, Houston, Minneapolis, San Francisco, Los Angeles, Seattle, Toronto, Springs (South Africa), Sydney (Australia). Sales Offices in Principal Cities. 13,047

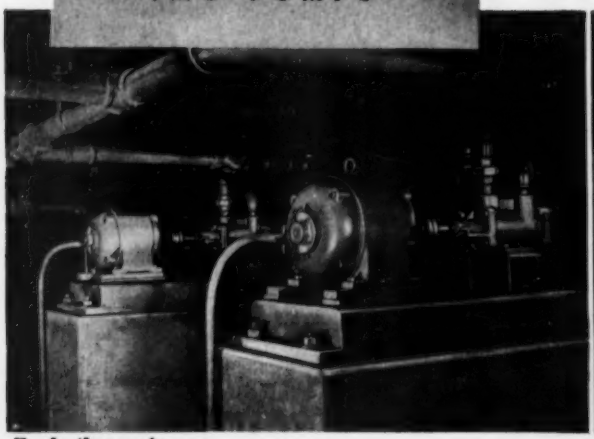
Double track dump hoppers and double reciprocating plate feeder serve inclined belt conveyor, extending to crusher. Additional Link-Belt conveyors carry material direct to steam plant bunker or to storage yard.

Note full load of lignite carried by Link-Belt inclined belt conveyor from hoppers to crusher. Inclined steel apron conveyor from yard coal reclaim hopper to belt conveyor is seen at top left.

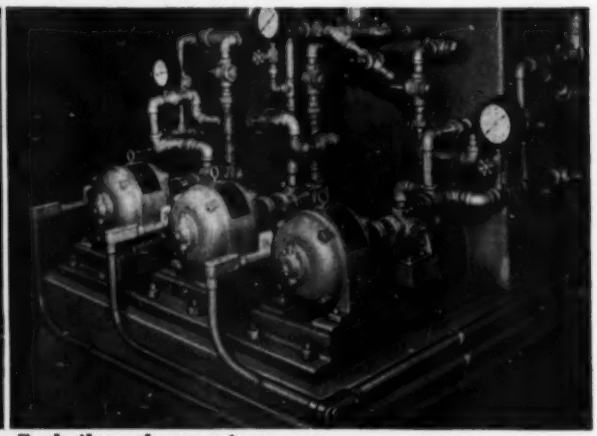
DE LAVAL

IMO PUMPS

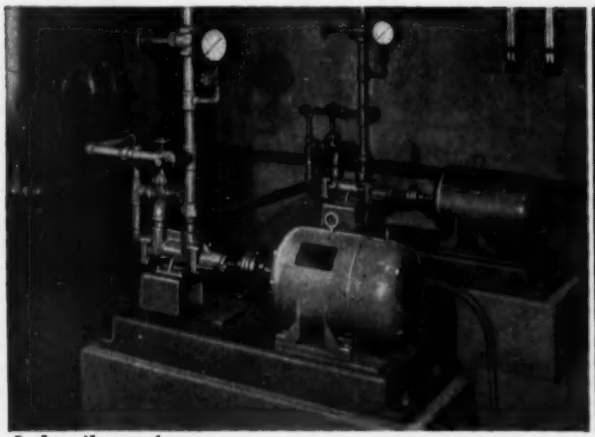
hold down 4 jobs at Owl's Head



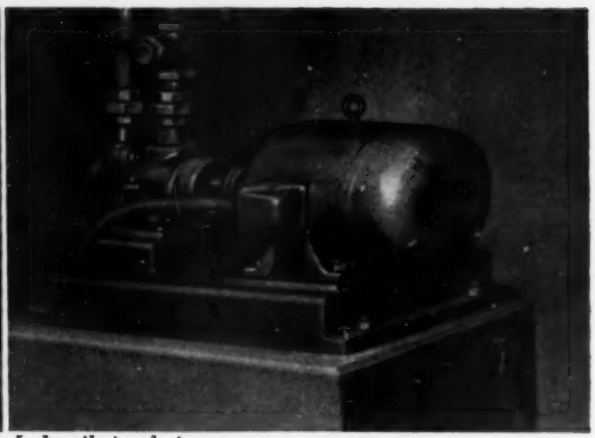
Fuel oil transfer



Fuel oil supply to engines



Lube oil transfer



Lube oil circulating

Again De Laval IMO rotary pumps prove their versatility. Eighteen of them are handling all the fuel and lube oil services for the six National Supply Company dual-fuel engines in the new Owl's Head sewage treatment plant in Brooklyn, New York.

The unique IMO design—*with only three moving parts*—assures long, trouble-free performance. IMO pumps are quiet, pulsation-free, compact and excellent for direct-connected high-speed operation.

Whether your power source is dual-fuel, gas or diesel engine, or oil-fired steam, be sure to specify IMO pumps for your next oil handling job. Use them in high and low pressure fuel oil burner sets, pumping fuel oil to burners, unloading and transferring fuel and diesel oil, handling oil for lighting off service and providing pressure lubrication on pumps and turbines. Send for Bulletin LG showing complete IMO line for capacities to 1,000 gpm at pressures to 500 psi and for capacities to 150 gpm at pressures to 1,500 psi.

IMO Pumps

DE LAVAL STEAM TURBINE COMPANY

857 Nottingham Way, Trenton 2, New Jersey

DL 157

Edited specifically for executives and engineers responsible for the selection, installation, operation & maintenance of equipment required for Engineered Plant Services*

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*By ***Engineered Plant Services*** we mean the ***providing*** or ***generating, transmitting, controlling, applying,*** and ***maintaining*** of POWER, STEAM, MECHANICAL DRIVES, HEAT, ELECTRICITY, AIR, WATER, and other engineered services in and for all areas of the industrial operation. This includes Lubrication, Piping Systems, Industrial Waste Disposal, CorrosionControl, Electrical Systems, Industrial Heat, Coal and Bulk Handling, Dust and Fume Control, and other related services of an engineering nature.

INDUSTRY AND POWER

The Magazine for Engineered Plant Services

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Vastly superior to old-fashioned *indicating* types, the new PROTO torque-*limiting* wrench quickly pays for itself by doing work better and faster! See and buy it at your nearest PROTO dealer. Send for free details (enclose 10¢ for 68-page catalog of the *complete* PROTO line) to:

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Acorns of science

Developments not yet available, but of interest to those responsible for Engineered Plant Services

Ceramics vs Temperature

● For some time ceramics have been proposed as a possible answer to high temperatures in aircraft. A practical step is being taken at Solar Aircraft Company where ceramic coatings for low alloy and mild steel are under development. Primarily intended for aircraft engine use, the company has already produced coatings which provide protection to low alloys up to 1200 F. However, the material will not replace high temperature alloys where strength is a factor.

A Billionth of an Ounce

● With a Van de Graaff type generator that is small but capable of producing two million volts, Stanford Research Institute has equipment that can detect as little as $1/10^{12}$ gram. Protons (hydrogen ions) are accelerated in a 20 ft vacuum tube by the generator potential and strike the substance being measured. Equipment similar to a mass spectrograph measures rebound velocity of the protons, which is proportional to mass of the molecule struck. The number of protons having a certain velocity measures quantity of material having the corresponding mass. Early studies may include chemical and physical properties of lubricants, behavior of surface reactions, study and measurement of coatings and finishes and analysis of aerosol samples.

Predict Electronic Failures

● As electronic equipment becomes more complicated and more widely used, reliability becomes more important. To help insure it, the National Bureau of Standards has developed equipment which is plugged into apparatus to be checked and identifies deteriorated stages and components. It has been able to predict failure of a military receiver in tests.

Gas Measurements

● A report of the National Advisory Committee of Aeronautics shows possibilities of a consolidated porous medium for determining flow rate and viscosity of gases. With normal laboratory techniques, calibration of large porous Alundum filtering thimbles to meter gas with probable error of 0.1 to 0.2 per cent appears possible. Geometry of filtering elements permits metering an appreciable range of gas flow rate with small accurately controlled pressure drops. Results of the tests have been employed in determination of air viscosity up to approximately 900 psia at both 75 and 517 F.

Renting Research

● Advantages in placing research projects with outside organizations were recently discussed by Dr. H. A. Leedy, director, Armour Research Foundation. Some of them are availability of highly trained specialists, economy of "renting" expensive equipment, added technical manpower for desired periods, contractual control, isolation from short term production problems, fresh viewpoints, administrative flexibility, objectivity and mutual desire of both sponsors and laboratories for successful research.

Floating Speed

● Patent No. 2,602,632 covers improvements in a high speed, rotary air bearing, short hollow shaft turbine, the rotor of which is both supported and driven by air. The stator has an internal cylindrical surface with outwardly flaring end surfaces. The rotor diameter is slightly smaller than the stator cylinder and has short outwardly flaring end abutments.

It's not what you pay - it's what it costs

There probably isn't a thing you buy that you couldn't buy cheaper. Provided, that is, you didn't figure the real cost—provided you weren't concerned with getting your money's worth. Right?

But you are concerned. You buy for longer wear. You buy for freedom from trouble. You buy for fewer repairs . . . for more dependable service. You buy equipment to be worked—not to be laid up. You know that thrifty buying isn't merely price-tag buying.

And it's to you, the thrifty buyer, that we like to sell Crane piping equipment. Whether it's a high pressure, high alloy valve or a ½" malleable pipe fitting, every unit in the Crane line is built to last longer with fewer repairs and lower servicing costs. That's why year in and year out thrifty buyers have put more Crane Valves in service than any other make.

Crane Co., *General Offices:* 836 S. Michigan Ave., Chicago 5, Illinois. *Branches and Wholesalers Serving All Industrial Areas.*

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VALVES • FITTINGS • PIPE • PLUMBING • HEATING

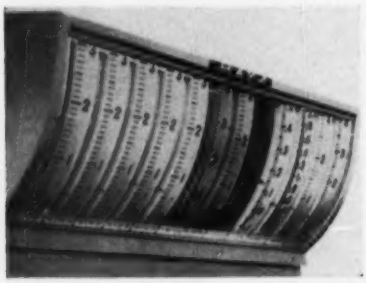
New equipment and developments

Highlights of new products by leading manufacturers

Each new product item has a key number for your convenience in asking for additional, detailed information. Insert key number on return post card on page 107

1—Draft gage has many advantages

Many desirable features are listed by The Hays Corp. for a draft gage known as Vertiscale. Among these features are: 3-way atmospheric vent;



easy "one man" zero check; large label space; magnetic access door; fluorescent lighting; removable units; no paralax; dust tight case; and Lucite scales. One to twelve units can be mounted in a single case. Four types of mounting are available.

2—Solvent cleans motors while in operation

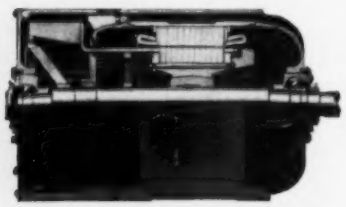
Motors and generators can be cleaned without disassembly by using a solvent manufactured by The Shaler Co. Cleaning is accomplished by operating the unit for 3 to 5 minutes while submerged in the solvent, or by spraying the product into the intake side of the motor while it is in operation. Motors accidentally submerged in water can be cleaned without baking. The solution does not affect gasoline or oil resistant wiring and insulation.

3—Flat-sided conduit for underground duct systems

Soapstone non-metallic conduit for concrete-encased underground power and communication circuits is now available in a flat-sided design. This permits multi-way duct systems to be built up quickly and accurately without the use of spacers required with round conduit, according to the manufacturer, Soapstone Duct Co.

4—High-slip motor features smaller size

For use in acceleration of high inertia loads such as punch presses, centrifuges and hoists, General Electric Company's Small and Medium Motor Dept. has developed a totally enclosed, fan-cooled, high-slip induction motor, type KRX. It is as much as 30 per cent smaller and 40 per cent lighter than conventional units of this type. Capac-



ities are 30 to 150 hp at 900 and 1200 rpm, with 5 to 8 and 8 to 13 per cent slip. Voltages are 220, 440 and 550.

5—Device controls carbon potential for heat treating

To permit the heat treater to set his atmosphere generator or furnace in equilibrium with any steel to be heat treated, Lindberg Engineering Co. has developed an instrument named the

Carbotrol. The unit automatically controls and records the carbon potential of furnace atmospheres produced by endothermic generators. In operation, the heat treater merely sets a pointer to the carbon content of the steel.

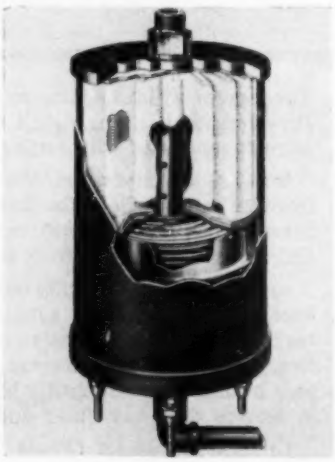
6—Flexible hose has unusual characteristics

Strength, flexibility, resistance to oil and abrasion, and ability to withstand high and low temperatures are char-

acteristics of Wiretex flexible, high-pressure rubber hose, according to Republic Rubber Div. of Lee Rubber & Tire Corp. It will withstand working pressures to 5500 psi and temperatures from -40 to 200 F. Standard sizes are ⅛ to 2 in. for hydraulic control hose. Other types are designed for such industrial requirements as steam, air and ammonia.

7—Unit filters and dehydrates compressed air

Instrument quality compressed air is provided by dehydrating and filtering ordinary plant air in the model B-30-D Condensifilter, according to the manufacturer, Hankison Corp. In op-



eration, the air is dehydrated as it passes through a water-cooled spiral condensing section. Dirt, oil and other contaminants are removed by a filter cartridge. The contaminants are then discharged through an automatic trap. Capacity is 30 cfm at 100 psi.

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JENKINS PRACTICAL PIPING LAYOUTS

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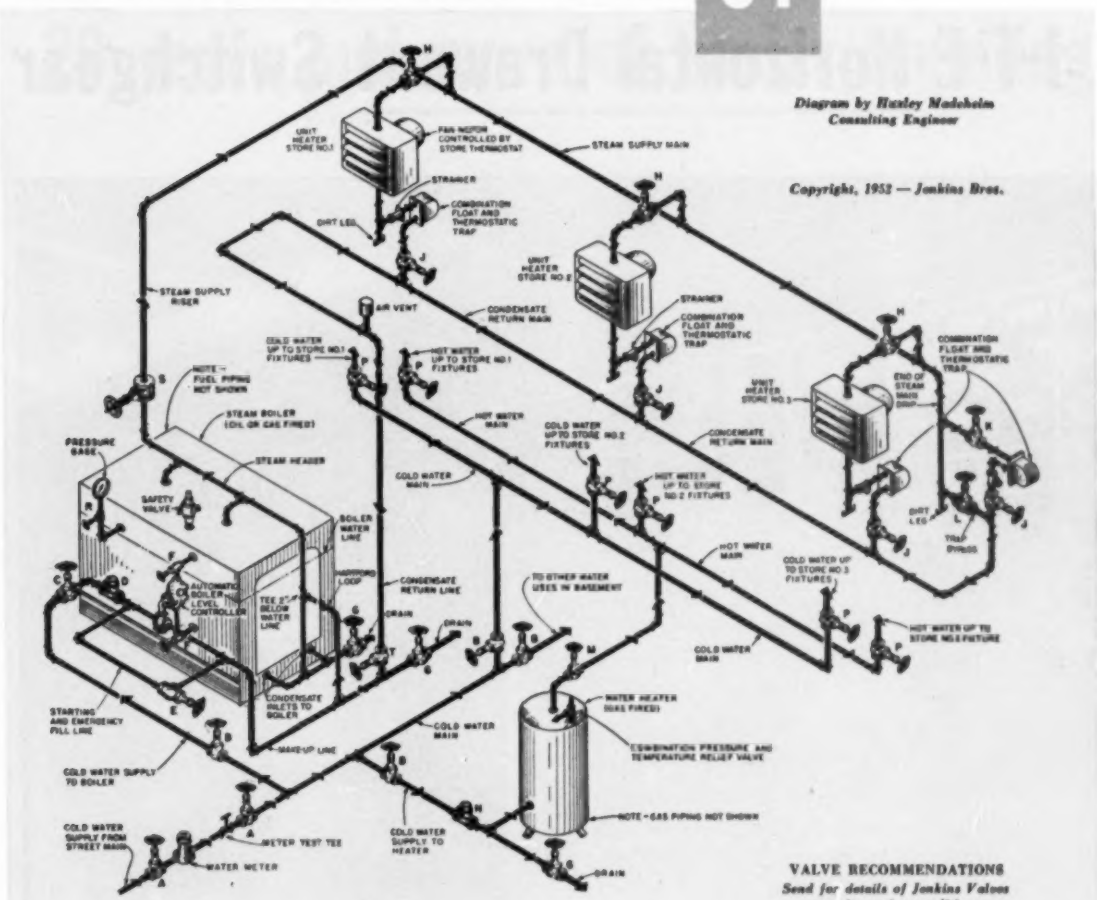
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Consulting Engineer
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STEAM SUPPLY MAIN
STEAM SUPPLY RISER
CONDENSATE RETURN MAIN
STEAM BOILER (OIL OR GAS FIRED)
STEAM HEADER
BOILER WATER LINE
CONDENSATE RETURN LINE
HOT WATER MAIN
COLD WATER MAIN
MAKE-UP LINE
COLD WATER SUPPLY TO BOILER
COLD WATER SUPPLY FROM STREET MAIN
WATER METER
METER TEST TEE
COLD WATER SUPPLY TO HEATER
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SAFETY VALVE
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STARTING AND EMERGENCY FILL LINE
CONDENSATE INLETS TO BOILER
TO OTHER WATER USES IN BASEMENT
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HOT WATER UP TO STORE NO.2 FIXTURES
HOT WATER UP TO STORE NO.1 FIXTURES
COLD WATER UP TO STORE NO.1 FIXTURES
COLD WATER UP TO STORE NO.2 FIXTURES
COLD WATER UP TO STORE NO.3 FIXTURES
END OF STEAM MAIN DRIP
YOKE BYPASS

VALVE RECOMMENDATIONS
Send for details of Jenkins Valves to suit varying conditions

Code	Quan.	Jenkins Valve	Service
A	2	Fig. 370 Bronze Gate	Water Service Shutoff
B	4	Fig. 370 Bronze Gate	Distribution Shutoff
C	1	Fig. 106-A Bronze Globe	Water Supply to Boiler
D	1	Fig. 92 Bronze Swing Check	Prevent Boiler Backflow
E	1	Fig. 108-A Bronze Angle	Emergency Boiler Fill
F	2	Fig. 108-A Bronze Angle	Level Controller Shutoff
G	3	Fig. 106-A Bronze Globe	Drains Shutoff
H	3	Fig. 106-A Bronze Globe	Steam Supply to Heaters
J	4	Fig. 370 Bronze Gate	Condensate Drain Shutoffs
K	1	Fig. 106-A Bronze Globe	Steam Main Trap Connection
L	1	Fig. 106-A Bronze Globe	Trap Bypass
M	1	Fig. 47-U Bronze Gate	Hot Water Heater Shutoff
N	1	Fig. 92 Bronze Swing Check	Prevent Water Heater Backflow
P	6	Fig. 370 Bronze Gate	Water Supply Shutoffs
R	1	Fig. 743-G Bronze Needle	Pressure Gage Control
S	1	Fig. 651 I.B.B.M. Gate	Steam Main Shutoff
T	1	Fig. 370 Bronze Gate	Return Shutoff

How to plan PLUMBING AND HEATING IN A SMALL TAXPAYER BUILDING

The one-story "taxpayer" building developed with the movement of shopping centers to suburban areas. Constructed with or without a basement, it houses retail stores, service establishments, amusement centers, restaurants and offices.

Heating and plumbing requirements of such a building are usually provided by the owner, whose main interest is economy and trouble-free operation. An oil or gas fired steam boiler with automatic controls, and a separate gas fired heater for hot water supply, as illustrated, is commonly used.

The two-pipe heating system, located in the basement, utilizes unit heaters hung from the ceiling to save space. Individual thermostatic controls assure fuel savings and even heating. A further refinement of the control system would include an automatic shutoff or modulator valve on the steam line just ahead of each heater, and an aquastat in the condensate return line from each heater. Piping is simple in such an installation and standard-type valves are used.

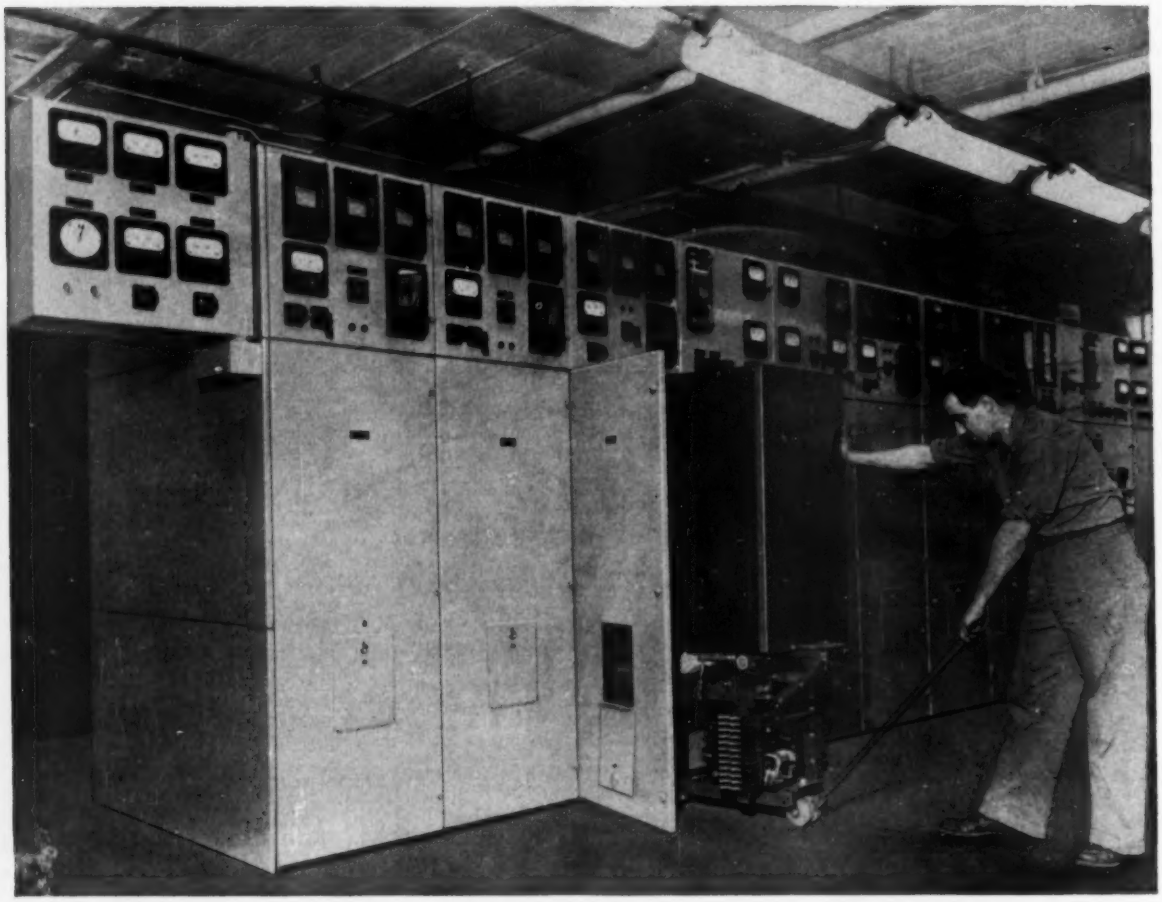
Consultation with accredited piping engineers and contractors is recommended when planning any major piping installation.

To save time, to simplify planning, to get all the advantages of Jenkins specialized valve engineering experience, select all the valves you need from the complete Jenkins line. It's your best assurance of *lowest cost in the long run.* Jenkins Bros., 100 Park Ave., New York 17.

Complete description and enlarged diagram of this layout free on request. Includes additional detailed information. Simply ask for Piping Layout No. 64.

JENKINS VALVES
LOOK FOR THE DIAMOND MARK
SINCE 1864

I-T-E Horizontal Drawout Switchgear



I-T-E Metal-Clad Switchboards complement latest engineering advances with neat, modern design. HV circuit breakers are easily withdrawn from compartments. Safety is the keynote.

Indoor and outdoor equipment in ratings: 4160 volts—50,000, 150,000, and 250,000 KVA interrupting 600, 1200, and 2000 amperes continuous

➡ 20 years and more of easier handling

Modern switchboards last 20 years or longer. During this period, you can expect periodic inspections, load changes, certain maintenance, and, of course, short circuits and overloads.

Consider the outstanding advantages to yourself of I-T-E *horizontal drawout* switchgear over the life of the equipment in each of the following instances:

When inspections are made

Truck-mounted circuit breakers can be wheeled out of compartments quickly and easily. Safety shutters isolate "live" contacts in the compartment. Connected equipment can then be examined carefully without danger to personnel.

When loads change

Relay settings are quickly adjusted to compensate for load changes. On wider load variations, current transformers may be changed. Isolation of compartments in Metal-Clad construction permits these changes without interference with the main bus. Circuit breakers may be removed from their compartments to assure complete safety. Horizontal drawout circuit breakers in drawout switchboards make this possible and *convenient*.

When maintenance is performed

Each circuit breaker is withdrawn from switchboard, checked, and adjusted if necessary. Service continuity is assured. While the circuit breaker is out of service, a spare can be used to replace it. One spare circuit breaker provides adequate insurance for many feeder circuits.

Your local I-T-E sales engineer will be glad to show you the specific advantages of Horizontal Drawout Switchgear in your own application. Or for complete details on I-T-E Metal-Clad Switchgear, send for Bulletin 7004-B, Dept. IR, I-T-E Circuit Breaker Co., 19th & Hamilton Sts., Philadelphia 30, Pa.

METAL-CLAD SWITCHGEAR

I-T-E CIRCUIT BREAKER COMPANY
19TH AND HAMILTON STREETS • PHILADELPHIA 30, PA.
I-T-E Equipment Division • Greensburg, Pa.

New equipment and developments

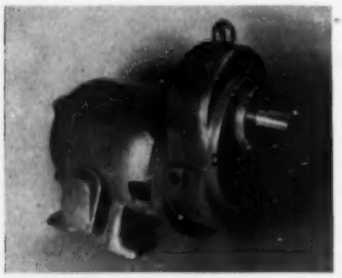
(Continued from page 8)

8—Control system eliminates storeroom condensation

Atmospheric condensation affecting items in storage can be avoided by an automatic control system engineered by The Foxboro Co. The controller, which keeps the temperature of stored material above the dew point of the air, takes the corrective action before moisture conditions develop. Application is discussed in a 2-page data sheet.

9—Gearmotor meets special mounting limitations

Westinghouse Electric Corp. has designed a Lifeline type B single-reduction gearmotor to meet mounting requirements peculiar to side entry agitators and mixers. It also is suitable for light duty coupled service applications such as fans and pumps. Ratings are 1 to 30 hp, 780 to 420 rpm, AGMA Classes I and II.

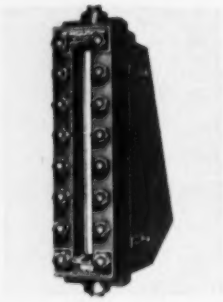


10—Instrument prevents excessive flow

For processes or equipment where pipeline flow is not to exceed a given value, Potter Aeronautical Co. has designed the Max-Alarm system. Having an 8 amp, 125 v built-in relay, it can be used to operate warning signals as well as to shut off a pump or close a motorized valve. Allowable pressures are to 20,000 psi at temperatures from 4 abs to 1200 F.

12—Illuminator permits accurate gage readings

Accurate gage readings of boiler water level are provided over long distances, through dusty air or deposits on the gage glass, or in poorly lighted areas, by a mercury vapor illuminator developed by Jerguson Gage & Valve Co. In operation, the water column shows blue-green, topped with a brilliant emerald green spot at the water level. Sizes, construction and installation are discussed in an available catalog.



TO REQUEST ADDITIONAL FREE DATA
Insert "key" numbers on return post card found on page 107. Our Reader's Service Department will handle your request promptly

13—Unit controls alternator frequency

General Electric Company's Special Products Section has designed a constant frequency control said to hold alternator frequency within 0.001 per cent on motor generator sets supplying up to 10 kw. Suggested applications include: stand-by power for automatic and synchronous equipment; power supply for high accuracy clocks and recorders; as a plant frequency standard; and for use with constant-speed mechanical drives. Units for 50, 60 and 400 c, single or three phase, are standard. It operates on 115 v, 50 or 60 c power, using approximately 150 w.

14—Instrument transformer extends ammeter range

Associated Research, Inc. has developed a large window, donut type, instrument current transformer to provide an inexpensive method of extending ammeter range to measure current flow in large conductors. Maximum OD of the model 321 is 5 in.; minimum ID is 2.25 in. and maximum thickness is 1.75 in. Ratios are from 1000 to 5 up to 2500 to 5, and capacity is 2.5 va. Specifications are listed in a data sheet.

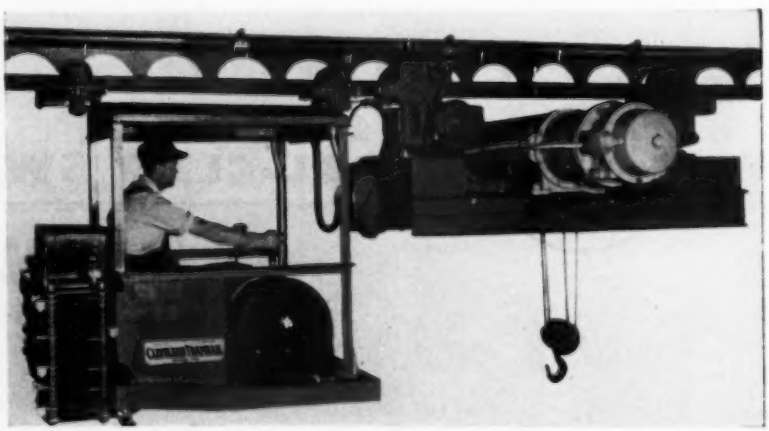
15—Inhibitor for use after wet blasting

To retard rusting of ferrous parts being cleaned and washed after wet blasting, American Wheelabrator & Equipment Corp. is marketing a liquid rust inhibitor known as Anarust. It is of organic composition, and contains no chromates. It is water soluble, nonirritating to the skin, and not subject to bacterial decomposition. It can also be used prior to such operations as plating, enameling and painting.

(Continued on page 16)

11—Overhead carrier is equipped with scale

Cleveland Tramrail Div. of The Cleveland Crane & Engineering Co. has designed an overhead traveling carrier equipped with a hydraulic cell scale to permit weighing of all loads handled. The cell is operated by a lever to which is fastened the upper hoist block. Resulting pressure is transmitted from the cell to the scale dial by hydraulic tubing. The motor driven tramrail carrier has a travel speed of 300 fpm. Hoist speed is 38 fpm with a 36 ft lift. Both travel and hoisting motors are provided with variable-speed controllers. In addition, the hoisting controller is designed for dynamic lowering. Load capacity is 3 ton. Variations of this unit can be made to meet other specifications.



From routine water treatment reports and water sample analyses, experts at Nalco Laboratories keep a complete record of your plant water treatment — can assist materially in maintaining permanent water treatment security.

How a *Nalco* WATER TREATMENT SERVICE AGREEMENT WORKS FOR YOU

OPERATION of your plant under a Nalco Water Treatment Service Agreement gives you two important safeguards against water treating problems in any form. First, Nalco will provide proper water treatment chemicals and procedures. Second, an experienced Nalco Service Representative will make regular visits to your plant, and is on call at any time to deal promptly with emergencies. Whether you have 10 or 10,000 BHP, this combination will provide what thousands of Nalco System users have learned to take for granted: *permanent water treatment security.*

Write, now, for full information on a Nalco Service Agreement for your plant.

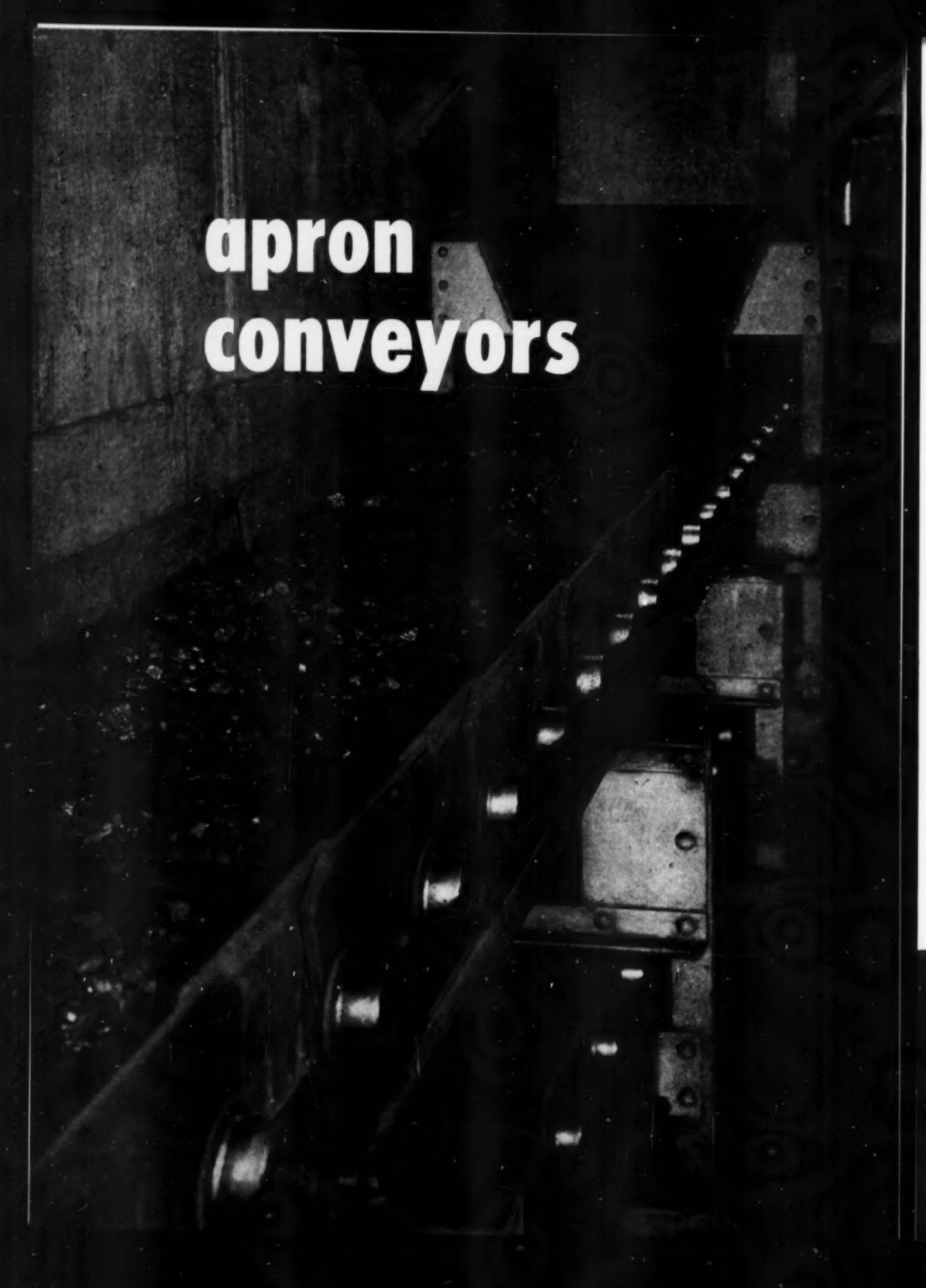
Nalco

SERVICE AGREEMENT SECURITY FEATURES

- **COMPLETE WATER TREATMENT SURVEY** of your plant by an experienced Nalco representative.
- **LABORATORY ANALYSES** of water samples . . . Initial complete analyses, followed by routine sampling and analyses as checks on plant tests.
- **RECOMMENDATIONS** of chemicals, testing and control procedures to establish water treatment security.
- **REGULAR CALLS** by a Nalco Representative to assure continuously successful treatment.
- **REPORT SYSTEM** to Nalco Laboratories gives cross-check on all phases of the Nalco System; enables keeping of complete performance records on your plant.
- **CONSULTING SERVICE** always available to assist in solving current problems — and in planning changes or additions to your plant which may affect water treatment.

NATIONAL ALUMINATE CORPORATION
6218 West 66th Place • Chicago 38, Illinois
Canadian inquiries should be addressed to Alchem Limited, Burlington, Ontario, Canada

THE *Nalco* SYSTEM • Serving Industry through Practical Applied Science


apron
conveyors

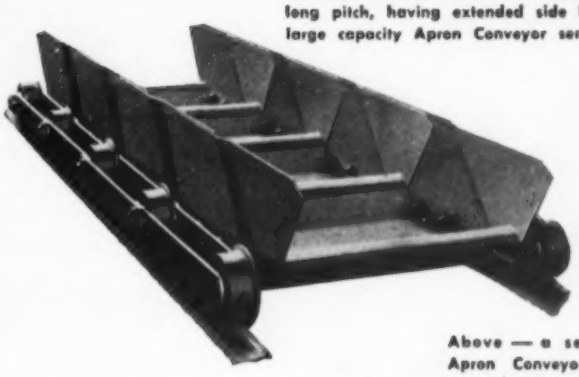
A section of Steel Thimble Roller Chain with long pitch, having extended side bars for large capacity Apron Conveyor service.

RUGGED CONVEYORS

Serving Many Diversified Industries

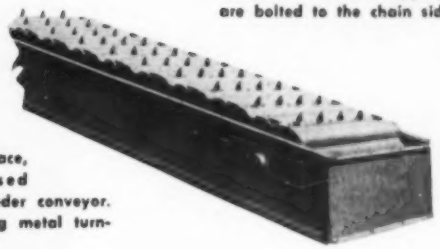
Coal . . . Coke . . . Crushed Stone . . . Burnt Lime . . . Hot Sand from Shake-out . . . Castings

Inclined or Horizontal . . . Can Be Made LEAK-PROOF

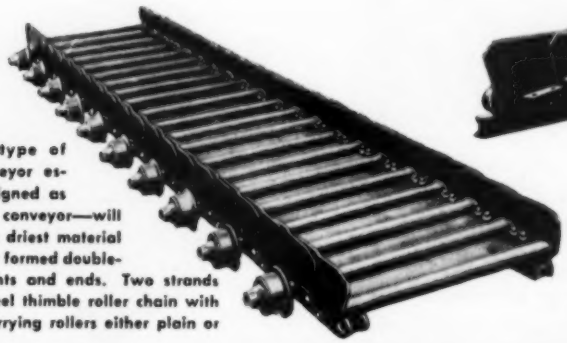


Above — a section of Apron Conveyor — depressed pan type. Mounted on Steel Thimble Roller Chain with flanged rollers for operating on rails as shown. The pressed steel bottoms are welded to the overlapping ends which are bolted to the chain side bars.

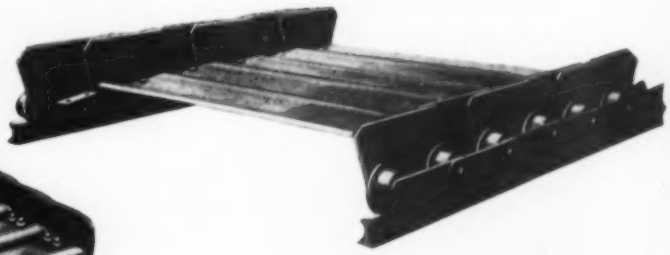
Jeffrey Apron Conveyors and Apron Feeders will provide all-day, continuous service. Send for additional information.



With tooth surface, this unit is used widely as a feeder conveyor. Ideal for feeding metal turnings to crusher.



A rugged type of Apron Conveyor especially designed as a shake-out conveyor—will not leak the driest material —accurately formed double-beaded flights and ends. Two strands of heavy steel thimble roller chain with outboard carrying rollers either plain or antifriction.



This section of Apron Conveyor has its ends formed by the extension of the chain side bars. The beaded and curved, or perfect discharge flights offer no resistance to flow of material.

THE JEFFREY MFG. CO.

Material Handling Processing and Mining Equipment

410 North Fourth St., Columbus 16, Ohio

New equipment and developments

(Continued from page 12)

16—Coolant pump features low cost

For use with small machine tools, Samuel S. Gelber Co. has developed a low cost, self contained coolant pump system. Known as Bantam, it incorporates only one moving assembly.

A flow valve gives instant adjustment from 0 to 400 gph. Capacity is 400 gph at zero head and 200 gph at 6 ft. A 1/30 hp fan cooled, all-enclosed motor operates on 110 v, single phase, 60 c. A data sheet is available.

17—Radio-frequency generators have high kva ratings

Westinghouse Electric Corp. has introduced two radio-frequency generators, rated 25 kw continuous at 450 kc in accordance with NEMA standards.

The tank circuit has a high kva rating, said to be the real measure of useful work that can be accomplished. One model is for relatively long production runs with infrequent readjustment, while another is available for short runs and quick set-up changes.

18—Unit combines pressure regulator and filter

Minneapolis-Honeywell Regulator Co., Industrial Div., has developed a compact unit providing the functions of a reducing-relief valve combined with a filtering arrangement for line service. According to the manufacturer, line pressures to 150 psi can be reduced and maintained at any regulated output pressure from 0 to 35 psi without appreciable drift or air consumption.

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Insert "key" numbers on return post card found on page 107. Our Reader's Service Department will handle your request promptly

19—Manometer rolls up for easy carrying

Field men will welcome the series 1211 flexible manometer, which rolls up to fit into a pocket or service kit. The unit, developed by F. W. Dwyer Mfg. Co., consists primarily of a vinyl-plastic body and a convexed spring

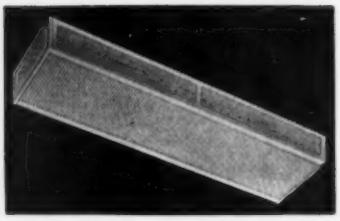
steel scale. Although held firmly, the scale can be easily adjusted for zero. U-tube units are available from 8 in. to 10 ft in water or mercury.

20—Pressure reducer features miniature size

Pressure measurements of pulsations in hydraulic systems and pipelines are simplified by a miniature pressure reducer, according to the manufacturer, Consolidated Engineering Corp. Known as type 4-310 Star Pickup, it has a flush diaphragm for insertion directly into a process vessel or stream of either liquid or gas. The unit is designed for use with recorders as well as visual indicators and meters. Specifications are given in a 6-page bulletin.

21—Louvre diffuser is for fluorescent lighting

Architectural beauty and lighting efficiency are said to be combined in a plastic louver diffuser created by the Edwin F. Guth Co. Designated Grate-Lite, the diffuser has been developed



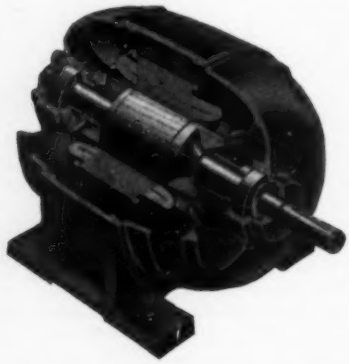
for use with fluorescent tubes and fixtures. Quality of light is said to be improved due to a lower apparent brightness caused by the lattice-like pattern. Sizes up to 4 ft in length are available.

22—Capacitor equipment is for ungrounded systems

For 15 kv ungrounded wye or delta systems, General Electric Company's Capacitor Dept. has developed new 300 kvar, open type, automatically switched capacitor equipment. A basic impulse level of 95 kv permits application on kv systems. The capacitors are mounted on pedestal insulators to provide increased insulation. Units also are supplied without switches for use as fixed capacitor equipment.

23—Motor provides positive lint expulsion

Designed for the textile industry, a screenless open motor developed by the Small and Medium Motor Dept. of General Electric Co. incorporates a simplified ventilation system combining effective cooling with positive lint expulsion. It will be offered first in special ratings for "Soft-Start" textile applications. Standard ratings of 2 to 15



hp at 1800 rpm, 1½ to 10 hp at 1200 rpm, and 2 to 7½ hp at 900 rpm will become available later.

24—Conveyer belt designed for sanitary applications

For applications requiring absolute cleanliness, Main Belting Co. has developed a conveyer belt with a dirt and abrasion resistant poly-vinyl coating. Pores of the belt are said to be so minute that they do not readily collect dust. In addition, the surface does not become soiled under normal operating conditions.

(Continued on page 20)

Any way you figure it, corrosion of steam and condensate lines is a serious problem . . . and a costly one! Replacement of corroded lines, interrupted production, increased labor and maintenance send costs spiraling far beyond the limits of economical plant operation. But something can be done about it *right now*, with complete assurance of satisfactory results.

Take the case, for example, of a large plastics molding plant which operated the cycle on its molding machines alternately with steam and oxygen-saturated cooling water. Under these conditions, severe corrosion resulted. Check valves on the steam supply lines to the machines had an average life of only one week—*sometimes even less!* Costs were skyrocketing.

Here's what Betz did about it. By applying its patented filming amine treatment, piping and valve losses stopped *immediately!* After three years' treatment with this advanced technique, satisfactory corrosion control continues. What's more, plant records show savings in labor and maintenance have averaged 30 times the cost of the treatment applied.

This is just one example of how Betz Engineers help keep plants *like yours* at peak operating efficiency. Why not get in touch with Betz today as the first step toward solving your particular water problems. There's no obligation, of course. W. H. & L. D. BETZ, Gillingham & Worth Streets, Philadelphia 24, Pa. In Canada: Betz Laboratories Limited, Montreal I.

For the full facts and figures on how BETZ is solving return line corrosion problems in plants like yours, write today for Technical Paper No. 124.

BETZ

CONSULTANTS ON ALL WATER PROBLEMS

"Experience showed us how FUSETRON FUSES Prevent Motor Burnouts . . . now we protect all Motors on our Units with them!"

Franklin Van Reed
Production Engineering Supervisor
ORR & SEMBOWER, INC., Reading, Penn.

"Here's what Happened in our Plant"

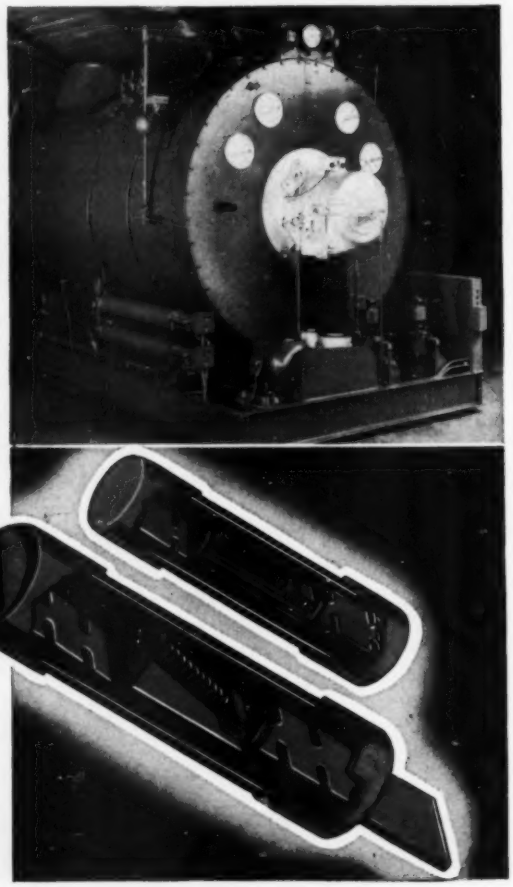
Back in January of 1951 we had a motor on a pump that was supposed to draw a maximum load of about 8 amperes, yet it began blowing FUSETRON fuses of motor protection size.

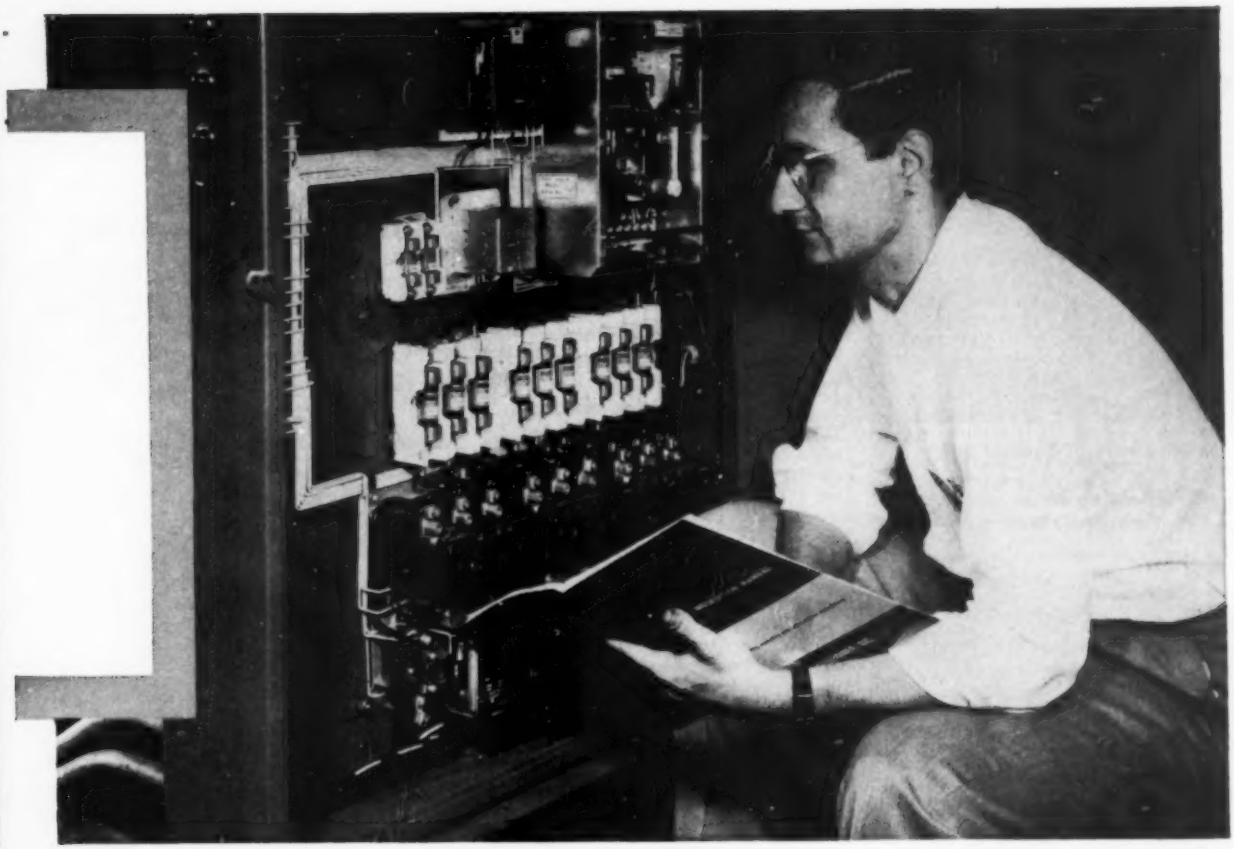
"We were inclined to believe something was wrong with the fuses — but after checking with an ammeter we found that an automatic relief by-pass was sticking and causing the motor to draw about 12 amperes.

"If the Fusetron fuses had not opened, the motor would undoubtedly have burned out.

"Now on all our Powermaster Steam Generator Units we use Fusetron Fuses to protect the motors on the fuel pump, the boiler feedwater makeup pump, and the air compressor."

Franklin Van Reed
Production Engineering Supervisor
ORR & SEMBOWER, INC.,
Reading, Pennsylvania





You, too, can profit by the

10 POINT PROTECTION of Fusetron Dual-Element Fuses . . .

1 Protect against short-circuits.*
2 Protect against needless blows caused by harmless overloads.
3 Protect against needless blows caused by excessive heating — lesser resistance results in much cooler operation.
4 Provide thermal protection — for panels and switches against damage from heating due to poor contact.
5 Protect motors against burnout from overloading.
6 Protect motors against burnout due to single phasing.
7 Give DOUBLE burnout protection to large motors — without extra cost.
8 Make protection of small motors simple and inexpensive.
9 Protect against waste of space and money — permit use of proper size switches and panels.
10 Protect coils, transformers and solenoids against burnout.

*Fusetron Fuses have high interrupting capacity as shown by tests of the Electrical Testing Laboratories of New York City in December 1947.

FUSETRON is a trade mark of the Bussmann Mfg. Co., Division of McGraw Electric Co.

THE MONEY YOU SAVE . . . by preventing one **needless** shutdown, one **lost** motor, one **destroyed** switch or panel or one **burned out** solenoid . . . MAY MORE THAN PAY FOR the replacement of all your ordinary fuses with Fusetron dual-element Fuses.

THIS COUPON WILL BRING YOU complete information about the All-Purpose Protection of FUSETRON Dual-Element FUSES

FUSETRON
TRUSTWORTHY NAMES IN ELECTRICAL PROTECTION
BUSS

Bussmann Mfg. Co., University at Jefferson, St. Louis 7, Mo. (Division of McGraw Electric Co.)

Please send me complete facts about FUSETRON dual-element Fuses.

Name_____

Title_____

Company _____

Address _____

City & Zone_____ State_____ 153

New equipment and developments

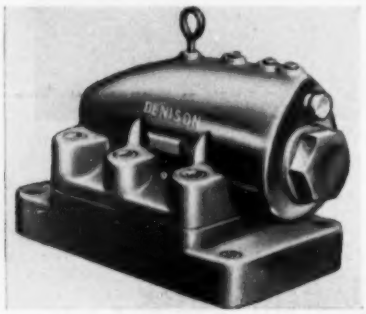
(Continued from page 18)

25—Fuel oil conditioner improves combustion

By replacing hydrogen atoms stripped from petroleum molecules during catalytic refining, an additive known as Oilate insures complete combustion, according to the manufacturer, American Additive Co. In addition to increasing thermal efficiency of the fuel, it is said to eliminate moisture, sludge and carbon deposits. It is recommended for all grades of burning oils.

26—Relief valve is for high pressures

Denison Engineering Co. has announced the addition of a 2 in. Hydr-OILic relief valve to their line of hydraulic equipment. It provides control up to 5000 psi with volume capacities to 125 gpm, and is available with either threaded body or for subplate mounting. Advantages claimed



for the valve include fast action, close pressure control and a reduction of over-pressure and pressure-drop conditions. Literature is available.

27—Thermocouple is for use with small masses

Many applications are suggested by the Industrial Div. of Minneapolis-Honeywell Regulator Co. for a thermocouple assembly, type J, developed to accurately detect temperatures in masses as small as plastic molds of 2 oz. It can be placed in the die or mold so that the measuring junction is as close as practical to the cavity. A compression sleeve facilitates rapid thermocouple replacement.

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Insert "key" numbers on return post card found on page 107. Our Reader's Service Department will handle your request promptly

29—Unit positions cylinder-operated devices

Accurate positioning of cylinder-operated devices is the function of the Poweractor positioner, introduced by The Foxboro Co. Operating from a standard 3-15 psi pneumatic controller signal, it applies a high pressure, pneumatic differential across a cyl-

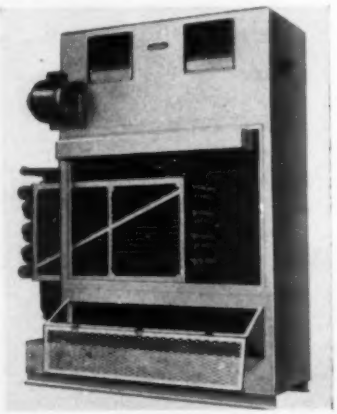
inder piston, sufficient to produce the position demanded by the controller. The units handle up to 150 psi air supply, depending upon cylinder rating.

30—Extreme pressure additive for lubricating oils

Molykote M-55 has been developed by The Alpha Corp. to serve as an extreme bearing pressure additive in forced-feed lubrication systems, and as an additive to cutting and coolant oils whenever the frictional component is important, such as in thread rolling and high speed forming operations. It consists of a colloidal dispersion of molybdenum-disulfide powder suspended in a synthetic vehicle compatible with any petroleum or sulfur base cutting or lubricating oil. Literature is available.

31—Evaporative condenser permits many arrangements

Flexibility of arrangement and accessibility, through use of building block construction and removable sectional components, are features of redesigned evaporative condensers manufactured by United States Air Conditioning Corp. Known as usAIRco model ECU, they are offered in six sizes with



capacities from 7½ to 40 ton. The units can be readily disassembled in the field and reset in any of 16 different arrangements.

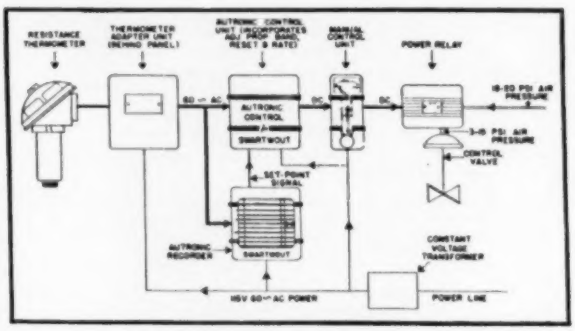
32—Thermoplastic cement has many uses

For general industrial use, the Industrial Div. of American Consolidated Dental Products Co. has announced a quick-setting thermoplastic cement. The product, known as F-88, does not require air for setting and is said to be permanent, even in hydrochloric acid. It can be used for gluing, bonding, filling and sealing most materials. The user prepares the cement by mixing powder and liquid to form a paste.

(Continued on page 24)

28—Packaged system controls and records temperatures

For controlling and recording temperatures, The Swartwcut Co. has announced a package based on units of the all-electronic Autronic control system. The package is composed of a temperature primary element transmitter, controller, recorder, manual control, power relay, and one or more constant voltage transformers depending on the needs of the individual installation. The manufacturer lists a number of advantages for this stystem. Among these are instantaneous and accurate response, unrestricted location of units comprising the system, adaptability to many different processes, interchangeability of components without recalibration, and low initial cost.



you DETERMINE THE COST OF cold

WHEN cooling water is manually controlled, the operator usually plays safe by running with everything wide open. Result—*overcooling*.

WHEN YOU OVERCOOL IN	YOU PAY MORE
1. Internal Combustion Engines and Compressors	by lower efficiency by impaired lubrication
2. Process work	by wasting 50% or more of cooling water used by increasing rejects
3. Refrigeration	for compressor power. For example, it costs 15% more to cool milk to 37°F than to 40°F.

Sarco dependable, self-operated cooling controls prevent overheating and overcooling and assure maximum efficiency at minimum cost.

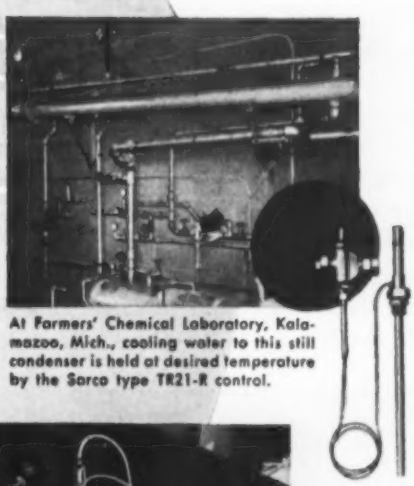
Four typical examples are shown in our illustrations. Hundreds more are in our files.

Ask for Catalog 700-13. Sarco Company, Inc., Empire State Bldg., New York 1, N. Y. Represented in principal cities. Sarco Canada Ltd., Toronto 8, Ontario.

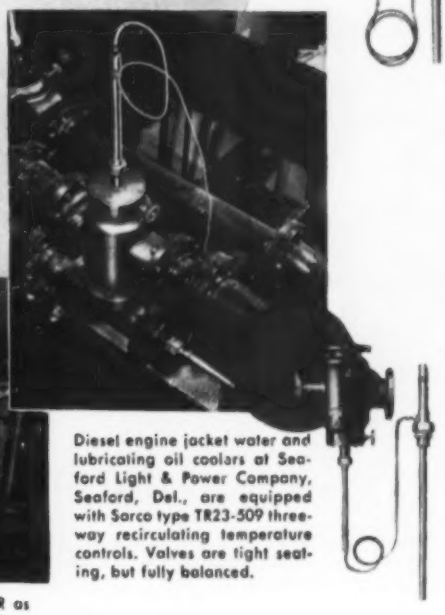
SARCO saves steam

a sarco regulator for every job

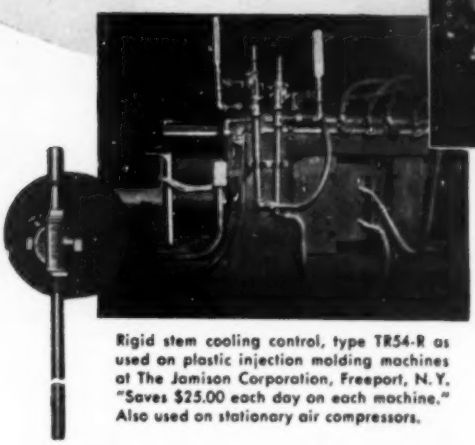
Schramm water-cooled stationary air compressors use Sarco rigid stem cooling controls, type TR44-R as a standard accessory. These Sarco Regulators protect the compressor, assure efficient operation and save water besides.



At Farmers' Chemical Laboratory, Kalamazoo, Mich., cooling water to this still condenser is held at desired temperature by the Sarco type TR21-R control.



Diesel engine jacket water and lubricating oil coolers at Seaford Light & Power Company, Seaford, Del., are equipped with Sarco type TR23-509 three-way recirculating temperature controls. Valves are tight seating, but fully balanced.



Rigid stem cooling control, type TR54-R as used on plastic injection molding machines at The Jamison Corporation, Freeport, N. Y. "Saves $25.00 each day on each machine." Also used on stationary air compressors.

430

valve values
PHOTO NEWS

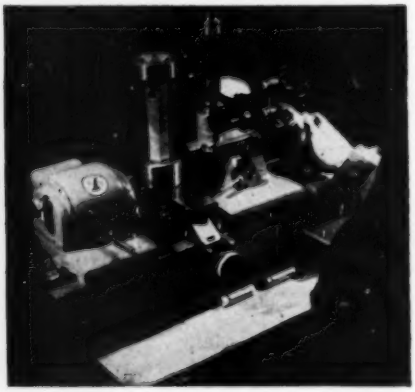
MICROMEASURING...
Edward Dimensional Control In Action

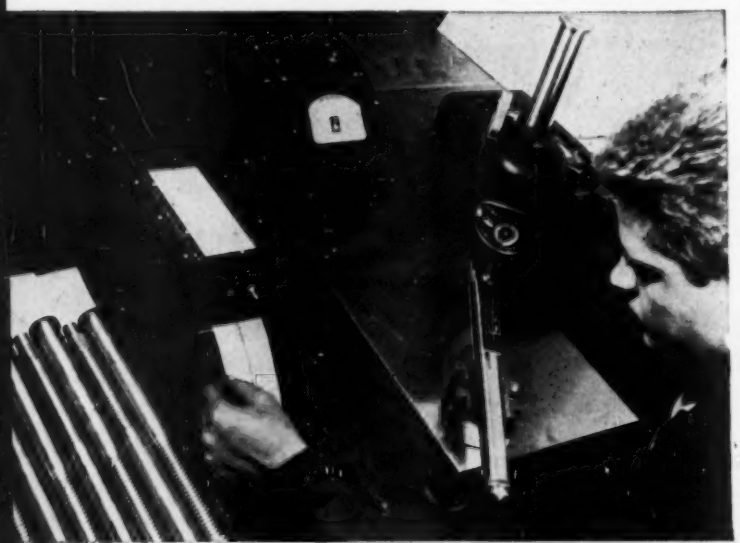
The young lady at right is operating the Micronoscope, a unique measuring device developed by Edward to check the all-important seat-disk joint on steel valves. Exclusive with Edward, this high vacuum inspection tool detects minute variations in surface finish and concentricity. If the joint is not vacuum-tight it is rejected!

Here at Edward we're well equipped with measuring devices of all types—and we use them often. For example, the components that make up each of the Fig. 7543 blow-off valves illustrated on the opposite page get 196 dimensional checks during manufacture. Regular inspections on all valves are performed at every manufacturing step by highly trained inspectors whose only responsibility is to double-check on the precision of our machines and men.

All this has a dollars and cents value for you. For this manufacturing accuracy, when added to Edward design and metallurgical leadership, results in valves that give long dependable service free from expensive shut-downs or high maintenance cost.

At Edward, the latest developments in optics, electronics, and other sciences are constantly searched for better methods of dimensional control. Above, optical contour projector magnifies image of stem for Fig. 952 instrument valve 62½ times, permits checking all tolerances to one ten-thousandth of an inch, all angles to one minute. Below, electrically operated Pratt & Whitney standards machine measuring accurately to within .000010 of an inch is used to check thread gage.





Electronic surface analysis test of stems for Fig. 4828 valves. Surface variations are measured in millionths of an inch, reproduced on chart in inspector's hand.

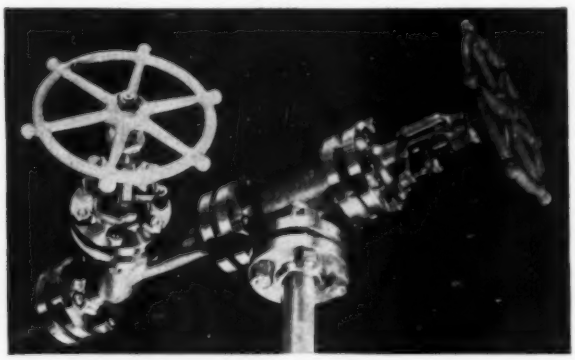
Edward Valves, Inc. Another Product

HOW TO SELECT AND OPERATE BLOW-OFF VALVES

A few special precautions in selecting and operating your blow-off valves will prolong their life, cut down on maintenance, and avoid trouble. For example:

1. Select two valves of identical design. This will permit interchangeability of parts.
2. During blow-down periods, first open the valve nearest the boiler wide, then slowly open the valve furthest from the boiler. In shutting down the valves, close the valve furthest from the boiler first, then close the valve nearest the boiler.

   This operating sequence places most of the wear on the valve furthest from the boiler and insures that a good tight valve is found nearest the boiler at all times. Should the valve furthest from the boiler, which is used as the blowing valve, show signs of excessive wear, seat erosion, etc., it can be removed from the line and repaired or replaced



without shutting down the boiler, while the valve nearest the boiler maintains boiler pressure.

3. Pick blow-off valves with the packing far removed from the high temperature zone. An extra feature in Edward valves is a positive backseat which seals off packing from the high temperature area.
4. Avoid gadgety-involved designs in selecting your blow-off valves. You're interested in long dependable service, not in trick construction.
5. The blowing valve should not be opened too quickly in order to avoid damaging shock to piping. Edward blow-off valves are of a special slow opening variety, and can be opened at normal speed, eliminating the possibility of error by inexperienced operators.

Many of your blow-off problems can be eliminated by selecting Edward valves, veterans of nearly fifty years of service in blow-off applications. With Edward you get a functionally simple design for greatest dependability. The use of identical valves permits maximum piping flexibility and interchangeability of parts. Disk is elevated from seat on operating instead of grinding against it, eliminating the possibility of seat-disk galling.

Provided in ASA pressure classes for 300, 600, 900 and 2500 lb, sizes 1½", 2", 2½"—straightway or angle, flanged or socket welding ends. Stellite or EValloy trim. Write for Catalog 12-D.

EDWARD VALVES, Inc., *Subsidiary of*
ROCKWELL MANUFACTURING COMPANY
40 W. 144th STREET • EAST CHICAGO, INDIANA

GLOBE AND ANGLE STOP • FEED-LINE • BLOW-OFF • NON-RETURN CHECK • GATE • GAGE AND INSTRUMENT • RELIEF • STRAINERS

Technical Tips

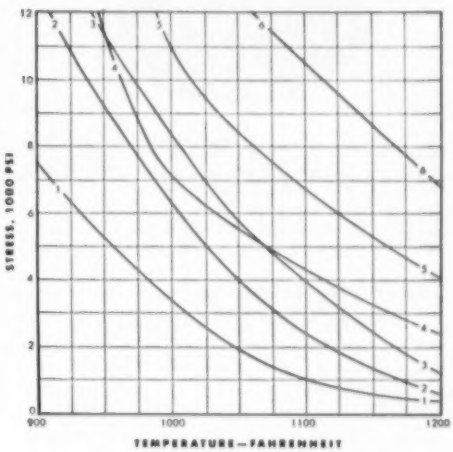
"Creep" Robs Metal Strength At High Temperatures

Steels stressed in a high temperature range show an unusual behavior—over a period of many days or years they may slowly stretch or bend out of shape. This phenomena is known as "creep". Some plastics do this at room temperature.

"Creep strength" rather than tensile strength limits the use of metals in valve design for high temperature use. This "creep strength", expressed in psi, refers to the load that can be carried by a metal without excessive plastic flow. The limiting plastic flow is most commonly considered as an increase in length of 1 per cent in 100,000 hours of time.

A single creep test must be run for 1,000 hours or more to measure this small rate of plastic flow. Each new type of metal to be investigated must be tested at several different loads to find the one which will most nearly cause plastic deformation at a rate of 1 per cent in 100,000 hours. Each set of tests must be repeated at several temperatures to cover the operating range in which the steel might be used. Hence, ten to twenty tests of 1,000 hours each are needed to find the creep strength of a single type of steel.

The creep strengths of six different steels often used in valve bodies for high temperature service are shown below.



CREEP STRENGTH VS TEMPERATURE

1. Low Carbon Steel
2. Carbon——0.50% Molybdenum Steel
3. 1.25% Chromium——0.50% Moly. Steel
4. 2.25% Chromium——1.00% Moly. Steel
5. 18% Chromium——8% Nickel Steel
6. 18% Chromium—8% Nickel—Mo. Steel

Creep testing in Edward laboratories.

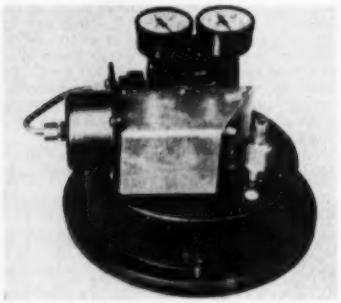
Edward

New equipment and developments

(Continued from page 20)

33—Pressure transmitter provides greater safety

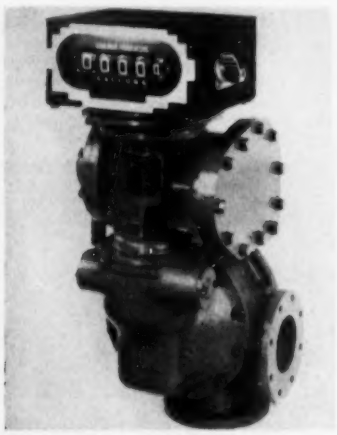
Penn Industrial Instrument Corp. has combined a pressure gage and a pneumatic transmitter, to form one instrument. Output of the transmitter varies from 3 to 15 lb, or 5 to 25 lb if specified, regardless of the range of pressure being measured. Gages range from vacuum to 10,000 psi. These units are said to provide greater safety and



convenience, particularly where high pressures or hazardous fluids are used. They permit use of low pressure air piping to bring indication or recording to remote locations. Literature is available.

34—Displacement meter handles corrosive liquids

Rockwell Manufacturing Co. has developed a rotary displacement meter, the 2 BC Rotocycle, to handle corrosive liquids common to chemical, food, rubber and pharmaceutical processing



industries. The new stainless steel industrial meter has a maximum capacity of 100 gpm at 125 psi working pressure. Remote registration and a quantity control register are among the features listed in an available bulletin.

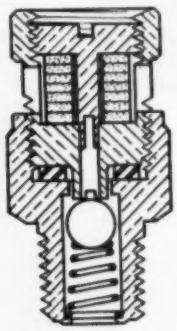
35—Chart drive is for hazardous locations

To permit economical panel installations in hazardous locations, Minneapolis-Honeywell Regulator Co. has developed the Macnick pneumatic chart drive. It is designed for use with Brown strip chart Tel-O-Set recorders. Explosion-proof housings and individually enclosed switch boxes are not required. Normal filtered air supply is used. Pressure can vary from 20 to 35 psi without affecting timing.

TO REQUEST ADDITIONAL FREE DATA
Insert "key" numbers on return post card found on page 107. Our Reader's Service Department will handle your request promptly

36—Unit vents steam or hot water systems

Automatic venting for either steam or hot water systems is provided by the No. 500 Universal air vent developed by Hoffman Specialty Mfg. Corp. A selector screw permits use for manual, steam or hot water venting. The manufacturer states that the valve can be cleaned without draining the water system. Installation can be vertical or horizontal. Maximum operating pressures are 15



psi for steam and 50 psi for water. Applications and construction are discussed in a 2-page folder.

37—Electric controllers are vapor actuated

Vapor actuated electric contact controllers for solenoid valves, warning signals and motors, have been developed by H. O. Trerice Co. to meet requirements of an accurate, dependable instrument that will stand relatively heavy electrical loads. Units for controlling temperature or pressure are available. A pilot light indicates position of the switch. Design features as well as engineering data are presented in a 2-page data sheet.

38—Wire grips are cold-forged

BullDog Electric Products Co. has announced that its silver coated Wire Grips are now available in quantity through its distributors. Five sizes cover all wire sizes from No. 14 wire to 1,000,000 Mcm cable. Principle advantage listed for the product is the cold-forging method of manufacture,

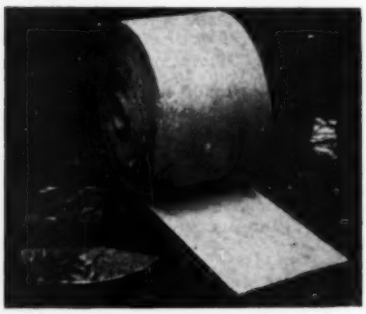
which is said to assure greater strength of the electrolytically pure copper from which the devices are formed.

39—Coating provides multiple corrosion protection

Protection against corrosion caused by atmospheric conditions, vapors, fumes, spillage and splash of chemicals, is said to be provided by a maintenance coating formulated by the Protective Coating Div. of Flexrock Co. The product, a plastic resin finish, dries entirely by solvent evaporation. Good adhesion is said to be provided over a wide temperature range.

40—Insulation features light weight

Ultrafine, a lightweight fine glass fiber insulation, has been designed by Gustin-Bacon Mfg. Co. for use where efficient thermal or acoustical insulation is needed, with minimum weight a consideration. Another outstanding property is its ease of handling, which permits economical installation. It is



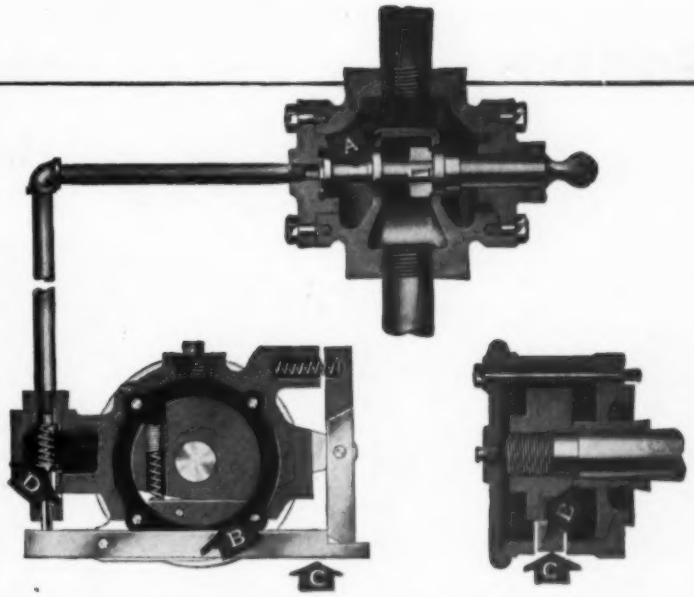
offered in rolls, either plain or with any of 5 different vapor barrier facings, or die-cut to any particular shape.

41—Larger unit added to transformer line

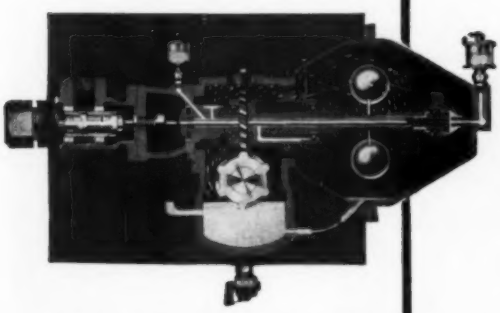
General Electric Company's Meter and Instrument Dept. has announced the addition of an 800 amp unit to their line of JKP-O indoor-outdoor butyl-molded transformers. It has a 150 per cent continuous rating, and is applicable to both single and three phase circuits. Mounting can be outdoors on poles or walls, and indoors in boxes or on walls.

(Continued on page 30)

Only Coppus Turbines offer you *a pilot operated* excess speed safety trip



The constant speed governor on Coppus Turbines, plus this Excess Speed Safety Trip, gives you extra protection for your turbine investments. Here's how it works. When steam is turned on, pressure opens valve A fully. When excess speed is reached, centrifugal force throws weight B against lever C lifting pilot valve D. This releases pressure in back of valve A, closing this valve instantaneously, to shut off the steam. Safety trip can be tested easily while turbine is running by manually tripping and resetting lever C.



Sectional view showing lubricating system of fully enclosed Coppus Constant Speed Governor. Governor head acts directly on stem of steam admission valve. No external levers required. Ball bearing construction eliminates end play and gives frictionless operation.

Coppus Turbines ranging from 150 hp down to fractional in 6 frame sizes

CUT YOUR COSTS PER HORSEPOWER

When you choose from the Coppus Steam Turbine line, you get the right size for your requirements . . . and make substantial savings on *any* size from the 150 hp turbine down to the smallest. Low in first cost, Coppus Turbines save you more money in the long run. Operating and maintenance costs are kept low by such other features as: large number of steam nozzles, controlled individually by manually operated valves; hard chromium plating on shaft at the stuffing box; replaceable cartridge type bearing housings; optional carbon ring packing assembly for back pressures up to 75 pounds.

WRITE FOR BULLETIN 135

COPPUS ENGINEERING CORPORATION, 181 Park Ave., Worcester 2, Mass. Sales offices in THOMAS' REGISTER.

COPPUS "BLUE RIBBON" TURBINES

CANTON Flo-tubes Trademark

MODERN WAY TO HANDLE COAL . .

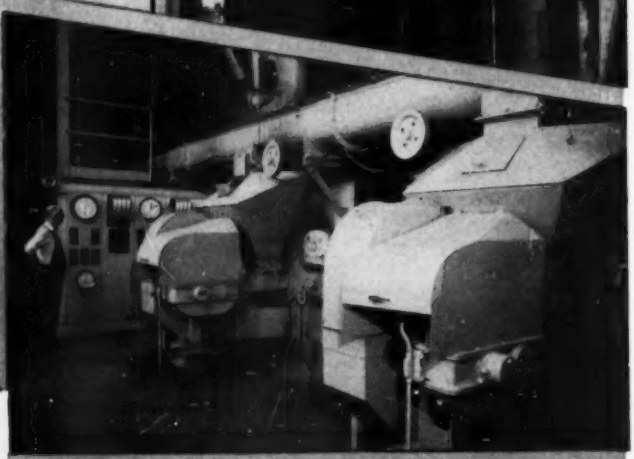
CANTON STOKERS

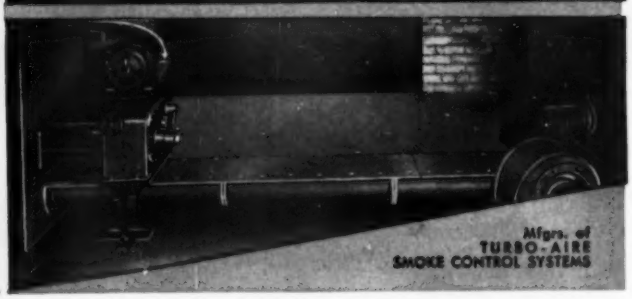
Feeding hoppers direct from pile or bin saves real money in time and man power . . . frees men for other duties, allows more efficient use of labor. Canton Flo-Tube installation above feeds from coal bin at right. Chute dividers are hand adjustable, hopper levels diaphragm controlled.

RIGHT photo—a horizontal application, using gate valves.

LOWER right photo—a reversed binfeed installation entering rear of boiler.

Canton Stoker Corporation — specialists in COAL FIRING, HANDLING, and CONTROL EQUIPMENT — invites you to contact their representatives in principal cities, or write direct.





Mfgrs. of TURBO-AIRE SMOKE CONTROL SYSTEMS

CANTON STOKER CORPORATION

403 Andrew Place S. W. CANTON, OHIO

☐ Send literature on:_____

_____

☐ Have a Canton Engineer interview us.

Name:_____

Company:_____

Address:_____

City:_____ State:_____

NOW...with the proved Cooper-Bessemer JS

THE above illustration diagrams the advantage you *now* stand to gain with the supercharged, aftercooled* Cooper-Bessemer JS-8.

Many a man who knows heavy-duty engines has wished for JS performance beyond the previous top rating of 1,000 bhp. And here it is . . . 1,450 bhp . . . with every cost-saving, trouble-avoiding feature for which the JS is noted, plus even *higher* efficiency thanks to aftercooling.

With almost 50% *more power* the record-setting JS can now do a bigger, better job than ever before — and with no appreciable increase in weight or space!

Check with the nearest Cooper-Bessemer office for the latest details.

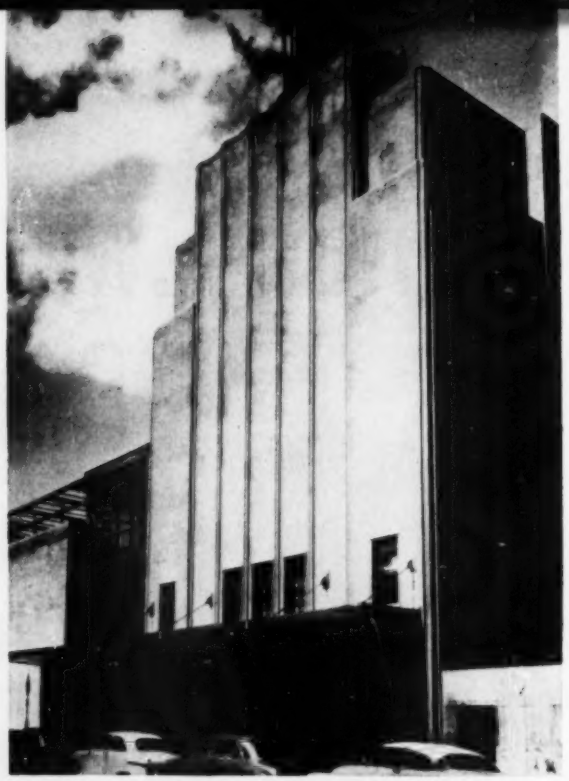
*Aftercooling water-cools combustion air between supercharger and intake manifold, thereby permitting more air for greater power and higher efficiency.

The Cooper-Bessemer Corporation

MOUNT VERNON, OHIO — GROVE CITY, PENNA.

New York Washington, D. C. Bradford, Pa. San Francisco Houston, Dallas, Greggton, Pampa and Odessa, Texas Seattle Tulsa Shreveport St. Louis Los Angeles Chicago Caracas, Venezuela Cooper-Bessemer of Canada, Ltd., Halifax, Nova Scotia Gloucester, Mass. New Orleans, La.

TELEVISION POWER BREAKER. The 500-kva G-E unit substations at WWJ-TV have voltage ratings of 4800-208Y/120, are equipped with Type AK-1-25 air circuit breakers.



WWJ's NEW BUILDING houses studios of Detroit's pioneer TV station. General Electric load-center system furnishes power for amplifying, lighting—other station requirements.

Detroit's new TV studios rely on

Power continuity assured for all studio requirements at WWJ-TV by secondary-selective distribution system

For the engineers of WWJ-TV—Detroit's pioneer TV station and an affiliate of WWJ, the world's first commercial radio station—a dependable source of continuous power rates first consideration in planning the new television studios. Total or even partial power shutdown cannot be tolerated.

At its new studios, WWJ-TV needs reliable power for lighting and amplifying . . . for its monitor panels and relaying equipment . . . for all station auxiliaries such as fans and blowers. To assure reliable power continuity for these many exacting requirements, Giffels & Vallet, Inc., L. Rossetti, associated engineers and architects, and Jack A. Frost, electrical contractor, installed a G-E secondary-selective load-center system consisting of two 500-kva unit substations.

With this distribution system, the station gains, too, in savings basic to load-center power. For example, a G-E engineered load-center system maintains consistent voltage for top operating efficiency, keeps voltage drop down to a minimum, provides less costly feeder breakers, and reduces cable costs.

Air circuit breakers, with ratings properly coordinated with transformer capacities, give adequate interrupting capacity and isolate troubles in feeders. Oil fuse cutouts are interlocked to prevent opening with load on transformers.

Flexible layout permits easy, quick maintenance without interruption of power. System flexibility itself provides for addition of new loads, making it far less costly for the station to expand in the future. Grounded, metal-enclosed G-E load-center units, with non-inflammable Pyranol* transformers assure maximum protection for operating personnel.

For further information on G-E engineered load centers, call your local G-E sales representative, or write for GEA-3592, General Electric Company, Schenectady 5, N. Y. 331-67

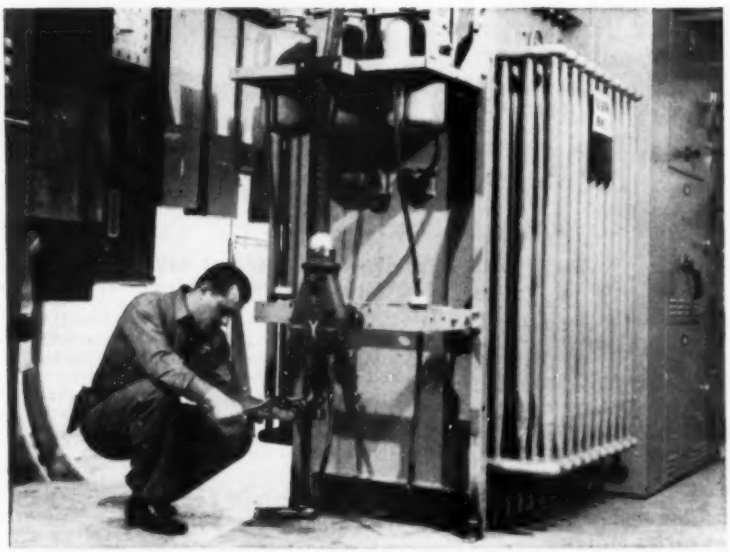
*Reg. Trademark of General Electric Co.

GENERAL ELECTRIC

1878 75 1953
YEARS OF ELECTRICAL PROGRESS

LIGHTS FOR TV PRODUCTION. Studio construction shot from WWJ-TV's control booth shows battery of lights necessary for televising. Lighting throughout the new station is fed from G-E engineered load centers.

G-E load-center system



CUTOUTS FOR PROTECTION. Engineer wires pothead of incoming high-voltage cable to cutouts on transformer of TV lighting breaker. Oil cutouts are interlocked, cannot be opened or closed with load on transformer.

PENOBSCOT BUILDING—Detroit's highest—houses all of WWJ-TV's transmitter equipment. TV antenna tops highest central portion. Here are transmitted programs originating in new studios powered by G-E load centers.

New equipment and developments

(Continued from page 24)

42—Portable unit saves greasing time

Important savings on greasing time are gained by using a portable high-pressure greasing unit, the 6-V Greasemaster, according to the manufacturer,

G & T Industries, Inc. The unit, which weighs less than 40 lb, obtains its power from conventional 6 or 12 v vehicle batteries. To increase its efficiency, a 25 ft length of 3000 psi hose is included.

43—Flexible steam hose is wire braided

Wire braided and glass cord construction are combined in the Ironsides steam hose, developed by Quaker Rubber Corp., Div. of H. K. Porter Co., Inc. It is designed for finishing work found in steel mills, refineries, glass factories and foundries, as well as for all types of steam cleaning. It is said to be flexible and kinkproof. Working pressures are to 200 psi. Sizes range from ½ to 1¼ in. ID.

44—Industrial crepe paper has high strength

Crepe paper having nearly three times the tensile strength of former industrial crepe paper and black varnished cambric, has been developed

by General Electric's Laboratory-Engineering Dept. Made from kraft and manila fibers, it is shown being wound on a brazed splice of coil lead and cable. It can also be used as insulating tape on some types of transformer coils. It is said to be less expensive and easier to apply than varnished cambric.

45—Lubricant is for wide temperature range

Plastilube, a lubricant developed by The Warren Refining & Chemical Co., is described as a stable chemical compound that does not contain metallic soaps or fatty acids, and therefore cannot melt or freeze. Its main use is in the lubrication of plain and antifriction bearings where temperatures range from sub-freezing to 500 F, and where water or moisture is a troublesome factor in breaking down ordinary greases. Other advantages listed for the product are adherence to metal surfaces without being affected by boiling water and excellent pumpability at low temperatures.

TO REQUEST ADDITIONAL FREE DATA
Insert "key" numbers on return post card found on page 107. Our Reader's Service Department will handle your request promptly

46—Sump pump features stainless steel shaft

Capacities to 3050 gph are provided by a vertical centrifugal sump pump developed by The F. E. Myers and Brother Co. Construction of the pump permits its use for many draining applications. All bronze construction, a

hydraulically balanced impeller and a stainless steel shaft are a few of the features listed.

47—Variable speed drive uses series motor

Higher speeds at medium torque, higher starting torque at slow speeds, and longer tube life are said to be gained by the use of a series motor in an electronic variable speed drive for fhp motors. This low cost packaged drive, developed by The Arrow-Hart & Hegeman Electric Co., is said to provide a wide, stepless range of speed

control with good speed regulation under varying loads. With an optional dual range feature, speeds from 100 to 3500 rpm are available.

48—Power pack is for air measuring instrument

For locations where 110 v supply current is not accessible, Hastings Instrument Co., Inc., has designed a battery operated power pack for use with their air velocity measuring instrument. The power pack incorporates a 6 v Hotshot battery and a con-

verter which provides 110 v a-c output. The meter provides a range of 0 to 6000 fpm.

49—Unit analyzes oxygen and combustibles

Bailey Meter Co. has developed a combination oxygen and combustibles analyzer for use with boiler furnaces, cement kilns, metallurgical furnaces, atmosphere control units, and other applications where economy and safety are important. It is said to provide almost instantaneous indication.

50—Air weight controller eliminates pulsations

For foundry cupolas, The Foxboro Co. has developed a compensator for their model 40 air weight controller. It is said to eliminate effect of blower pulsations on control and to automatically correct the rate of air flow for variations in atmospheric temperatures and pressure.

—End

Why Corrosion Costs You More Than Wrought Iron...

When you see a pipe repair job in progress, the economy of using durable material becomes obvious. Original installations are quickly made by pipe fitters. But repairs call for hours of work by as many as five crafts: pipe fitter , mason , carpenter , plasterer , painter .

Thousands of users in every industry are finding the profitable answer in Byers Wrought Iron pipe . They know that "cost per year of service" is the only true measure of economy. Service records have proved that Byers Wrought Iron pipe is still good after serving three or four times longer in areas where vulnerable pipe has failed.

With today's maintenance costs on the increase, selecting the pipe that lasts longer, at lower cost per year, is more important than ever before. The wide-spread and continued use of Byers Wrought Iron pipe in installations where corrosion is a threat to service life endorses the material's ability to give this essential durability. You'll find the facts responsible for this greater "life-span" in our bulletin, THE ABC's OF WROUGHT IRON. Write for your copy.

A. M. Byers Company, Pittsburgh, Pa. Established 1864. Boston, New York, Philadelphia, Washington, Atlanta, Chicago, St. Louis, Houston, San Francisco. Export Division: New York, N.Y.

BYERS

CORROSION COSTS YOU MORE THAN WROUGHT IRON

WROUGHT IRON

TUBULAR AND HOT ROLLED PRODUCTS

ELECTRIC FURNACE QUALITY ALLOY AND STAINLESS STEEL PRODUCTS

A Typical Report of a GRAVER DEAERATING HEATER

GUARANTEE: *Exceeded*

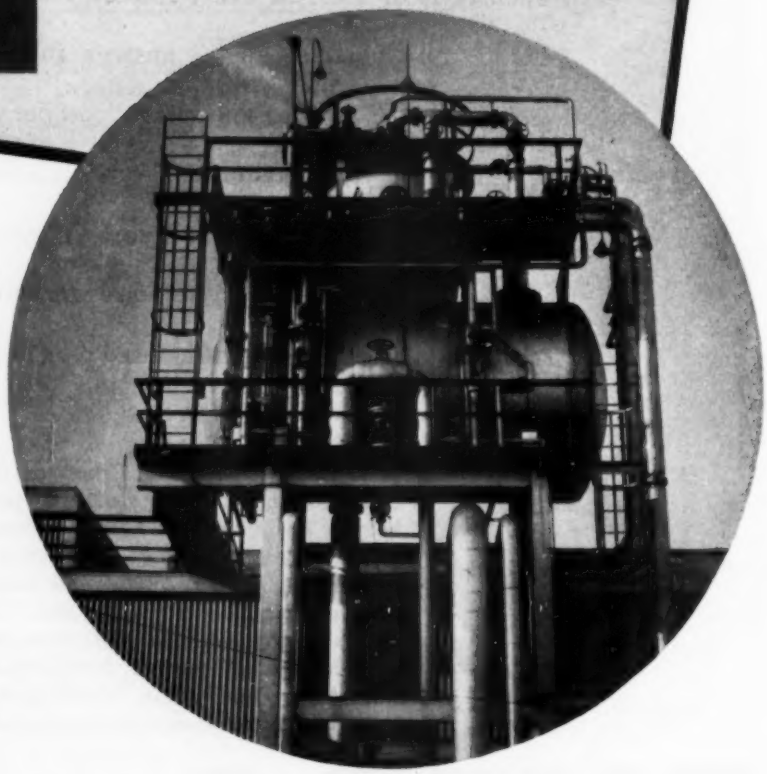
SERVICE: *Excellent*

The installation: A prominent Eastern petroleum refining company.

The unit: Graver Spray-Type Deaerating Heater delivering 450,000 pounds of feedwater per hour to 650 psig waste heat boilers.

The requirements: To remove up to 100 ppm CO_2 and 12 ppm O_2 under all load conditions with water at 60°F. Guarantee - 0.005 ml/l of O_2.

The performance: Average of 0.0047 ml/l of O_2 certified by an independent consulting engineering laboratory, and with completely trouble-free service.



The important point about this report is that it is *typical* of Graver Deaerating Heater performance, even under difficult load variations or water conditions.

Graver Heaters are available in a *complete range* of sizes in spray, tray, or combination spray-tray types. Graver Heaters are individually tailored to your exact plant requirements . . . that's one of the reasons why Graver's guarantee and service can be depended upon.

Write for free copy of "Trends in Application of Deaerating Heaters for Treatment of Boiler Feedwater".

GRAVER WATER CONDITIONING CO.

Division of Graver Tank & Mfg. Co., Inc.

DEPT. IP-A, 216 WEST 14TH STREET, NEW YORK 11, N. Y.

GRAVER

GW481

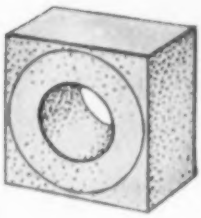
B&W KAOCAST goes in more furnaces because...

Versatile B&W Kaocast can be molded quickly and easily with your own labor. It can also be cast directly in place or applied with a cement gun. This unique 3000 degree refractory castable has high resistance to spalling and slag attack, low volume change and negligible reheat shrinkage. Consult a B&W Refractories Engineer on your specific applications and see how B&W Kaocast can save money for you.

It cuts inventory

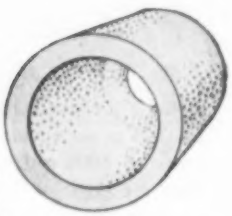
Nose arches for oil heaters were formerly made with special shapes of ordinary firebrick. Switching to quickly moldable Kaocast eliminated need for expensive special-shape inventory . . . minimized delays. In addition, side by side tests proved that Kaocast far outlasted the ordinary firebrick.

It speeds repairs



Kaocast was specified for the charging front of a forging furnace, used to heat heavy pipe ends. The reason? Kaocast linings were molded faster . . . give longer service, could be made when convenient and stored 'til needed.

It lasts longer



A chemical plant found that burner tile for a heating furnace made of an ordinary castable stood up only 3 to 4 months. But Kaocast burner tile stayed on the job 16 months and longer. Thousands of pounds of Kaocast have been used for this and many other applications in this plant.

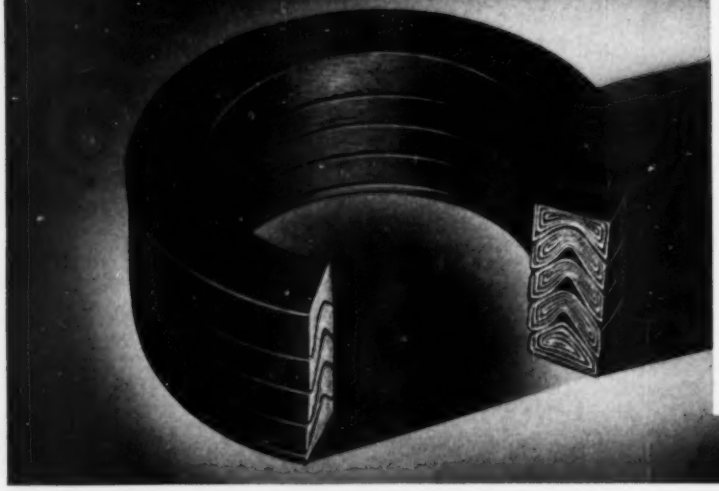
BABCOCK & WILCOX

THE BABCOCK & WILCOX CO.
REFRACTORIES DIVISION
GENERAL OFFICES: 161 EAST 42nd ST., NEW YORK 17, N.Y.
WORKS: AUGUSTA, GA.

R455

B&W REFRACTORIES PRODUCTS — B&W Allmul Firebrick • B&W 80 Firebrick • B&W Junior Firebrick • B&W Insulating Firebrick B&W Refractory Castables, Plastics and Mortars • OTHER B&W PRODUCTS — Stationary & Marine Boilers and Component Equipment... Chemical Recovery Units . . . Seamless & Welded Tubes . . . Pulverizers . . . Fuel Burning Equipment . . . Pressure Vessels . . . Alloy Castings

What is your special packing problem?



- ☐ Pressure
- ☑ Maintenance
- ☐ Acids
- ☐ Alkalis
- ☐ Complicated inventory
- ☐ Temperature
- ☐ Petroleum products
- ☐ Food products

If it's maintenance . . .

use R/M Vee-Flex® — the packing that provides better sealing with fewer gland adjustments

The unique design of the R/M Vee-Flex Packing Ring provides automatic sealing without constant gland adjustment. The hydraulic principles of this design have been demonstrated by photoelastic stress analyses* and radial pressure tests.*

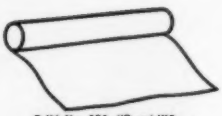
R/M Vee-Flex Rings are available for all sizes of rods and rams, and for pressures of 6000 psi and higher. Special types are available for use with foods and petroleum products.

Whatever your packing problem, the authorized R/M distributor near you has a packing engineered to your needs and your budget. Call him today or write us for the R/M Packing Catalog.

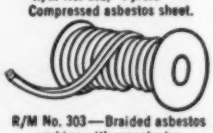
R/M is ready to meet your requirements for Teflon Packings, Gaskets, Rods, Sheets, Tubes and Tape.

*Performed at the Franklin Institute Laboratories for Research and Development.

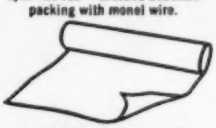
**Du Pont trade-mark for its tetrafluoroethylene resin.



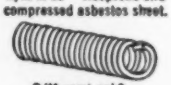
R/M No. 650, "Pyroid"*— Compressed asbestos sheet.



R/M No. 303—Braided asbestos packing with monel wire.



R/M K-68—Neoprene and compressed asbestos sheet.



R/M versi-pak*— For general use.

R/M Teflon** Nos. 830, 836— For acids, caustics or chemicals.

R/M

PACKINGS

RAYBESTOS-MANHATTAN, INC.

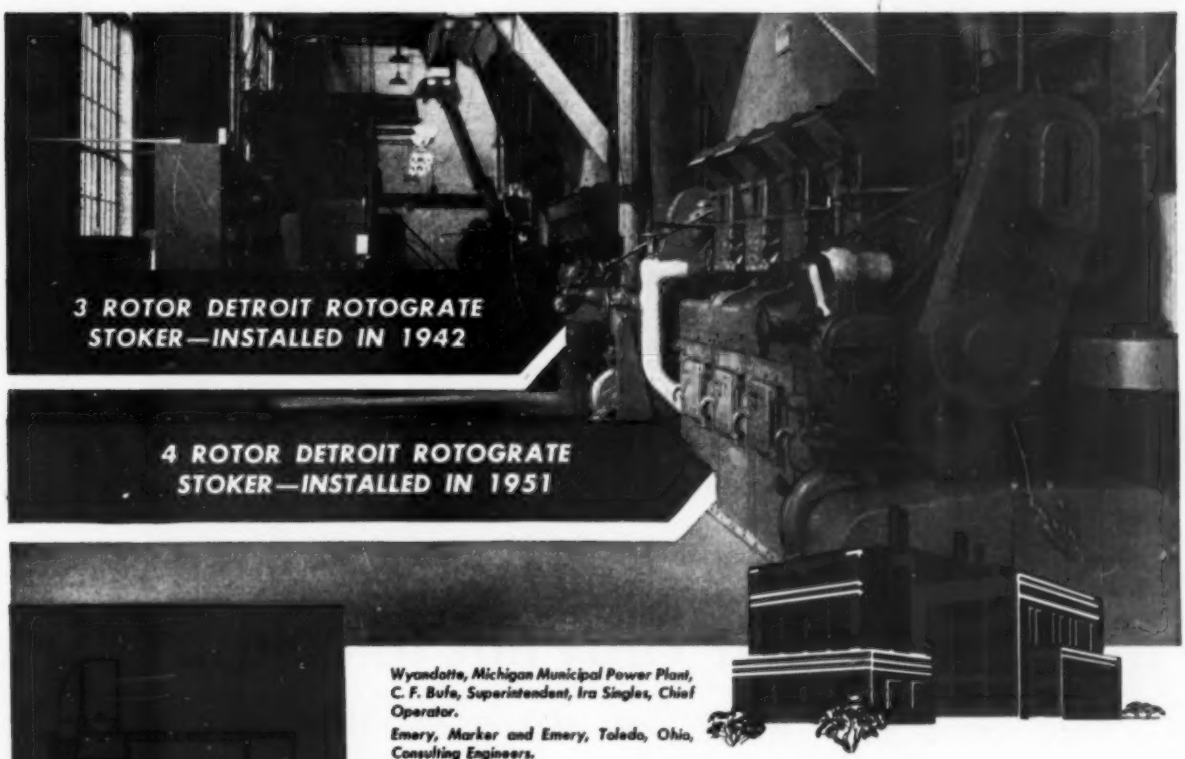
PACKING DIVISION, MANHEIM, PA.

FACTORIES: Bridgeport, Conn., Manheim, Pa., Passaic, N.J., No. Charleston, S.C. Crawfordsville, Ind., Canadian Raybestos Co. Ltd., Peterborough, Ontario, Canada

RAYBESTOS-MANHATTAN, INC., Manufacturers of Packings • Teflon Products • Asbestos Textiles • Industrial Rubber Products • Abrasive and Diamond Wheels
Rubber Covered Equipment • Brake Linings • Brake Blocks • Clutch Facings • Fan Belts • Radiator Hose • Sintered Metal Products • Bowling Balls

Detroit RotoGrate Stoker's ability to burn wartime coal Brought Repeat Order—

Municipal Plant, Wyandotte, Michigan



Wyandotte, Michigan Municipal Power Plant, C. F. Bufe, Superintendent, Ira Singles, Chief Operator.
Emery, Marker and Emery, Toledo, Ohio, Consulting Engineers.

In 1942, the Municipal Plant, Wyandotte, Michigan had coal trouble, as did most plants with old type firing equipment. It became almost impossible to operate on the coal they could get.

They purchased a Detroit RotoGrate, which solved their fuel problem immediately. The RotoGrate proved able to burn efficiently any coal available including the poor stuff which war conditions often forced them to use. In the fall of 1951 when they expanded the plant the Detroit RotoGrate was again the stoker chosen.

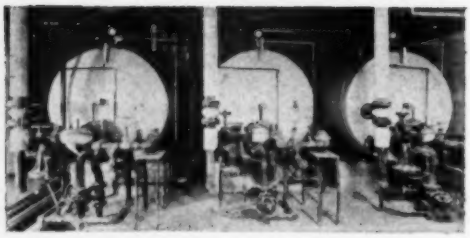
Detroit RotoGrate is a modern type spreader stoker with grates that move slowly forward, discharging ash at the front. A RotoGrate installation makes it possible to buy the most economical coal, and burn it with highest economy.

Write for Bulletin.

DETROIT STOKER COMPANY

General Motors Bldg. • Detroit 2, Michigan

WORKS AT MONROE, MICH. • District Offices in Principal Cities



when your water runs hot to cold...

... better call p-k *for a new look at your hot water supply*

ENOUGH clean, hot water when needed is vital for people or processes—utility services or plant operations. You get dependable hot water supply with a balanced installation of p-k hot water storage heaters.

Proved in long-time service in thousands of installations—in laundries, hotels, institutions, commercial buildings and general industry—p-k hot water storage heaters are the most dependable your money can buy—to save you money.

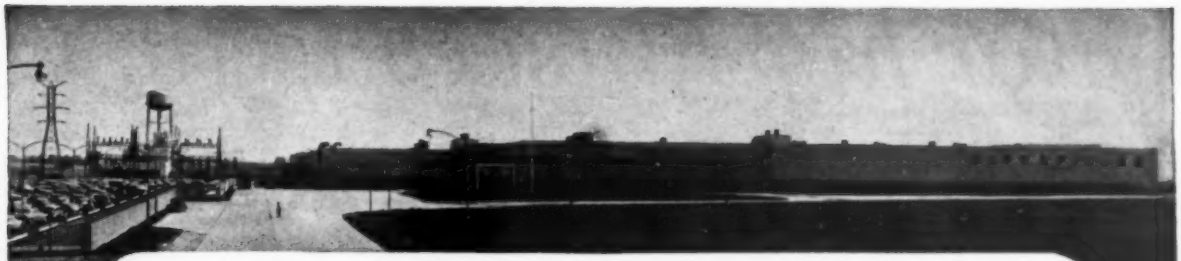
This dependability and overall efficiency is bred from decades of concentrated experience in designing and building storage heaters and other heat exchange equipment. p-k engineering experience shows you the right type of heater that will serve you best—whether the shell be carbon steel, copper silicon, copper lined, copper clad, galvanized or cement lined—vertical or horizontal. One type is right for any specific installation, depending on the liquids you handle and the results you require. p-k engineers know all the answers, place your confidence in them.

Before you settle on plans for new and better storage heaters, why not ask the p-k experts, who have been designing and making dependable storage heaters since 1880. 1915

the **Patterson-Kelley Co.,** *Inc.*

1110 Burson St., East Stroudsburg, Penna.

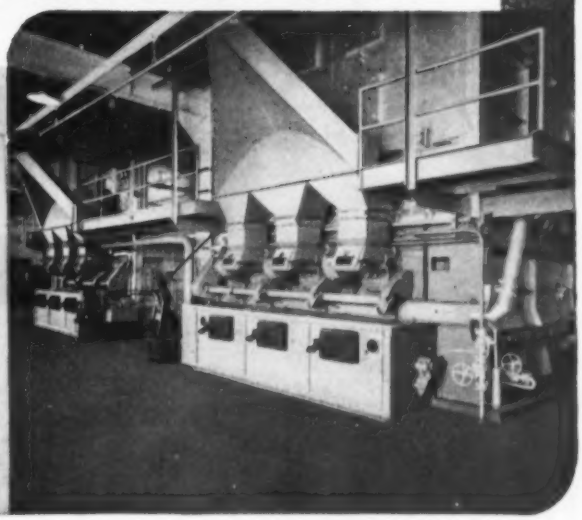
101 Park Avenue, New York 17 • Railway Exchange Building, Chicago 4 • 1700 Walnut Street, Philadelphia 3 • 96-A Huntington Avenue, Boston 16 • and other principal cities



NEW PLANTS LIKE CATERPILLAR'S BURN COAL THE MODERN WAY!

**Mr. R. H. Bachman,
Plant Maintenance Engineer,
Caterpillar Tractor Co., says:**

"Our new plant pictured above was recently completed at Joliet, Illinois. A completely up-to-date coal installation was chosen to handle the heat and process steam requirements. To the right is a picture of the firing aisle showing how the boilers are fed by dust-tight chutes from overhead bunkers. This modern equipment makes coal as clean, convenient, and efficient as a fuel can be! The boilers are rated at 80,000 lbs. of steam per hour, but have handled loads as low as 3,000 lbs. per hour without difficulty."



For big savings, build for COAL! That's a good rule to follow whether you've got a new plant under construction or an older plant being modernized.

Up-to-date coal-burning equipment can give you more steam per dollar . . . modern coal- and ash-handling systems can cut labor costs to a minimum. In addition, coal is the only fuel with virtually inexhaustible reserves. And to mine this coal, to better prepare it for customers' special needs, America has the world's most productive coal industry. Thus, coal users get a double advantage—*dependable supply of an even better product, at relatively more stable prices.*

For heat, power, process steam—coal is your best bet! Ask a consulting engineer. He'll show you how to cut both fuel and operating costs by burning coal in a modern plant designed to meet your specific needs.

If you operate a steam plant, you can't afford to ignore these facts!

COAL in most places is today's lowest-cost fuel.

COAL resources in America are adequate for all needs—*for hundreds of years to come.*

COAL production in the U.S.A. is highly mechanized and by far the most efficient in the world.

COAL prices will therefore remain the most stable of all fuels.

COAL is the safest fuel to store and use.

COAL is the fuel that industry counts on more and more—for with modern combustion and handling equipment, the inherent advantages of well-prepared coal net even bigger savings.

BITUMINOUS COAL INSTITUTE

A Department of National Coal Association, Washington, D. C.

FOR HIGH EFFICIENCY FOR LOW COST

YOU CAN COUNT ON COAL!

"For high dust collection efficiency CONSIDER THESE FACTS!"

95% to 99% REMOVAL

Your specific needs determine the exact percentage of fly ash removed by a Research Corporation Cottrell Precipitator.

LOW DRAFT LOSS

The pressure drop between inlet and outlet of the Cottrell is extremely low, averaging *only a few tenths of an inch of water.*

DURABILITY

Low velocities hold abrasion to a minimum.

ANY CAPACITY

Cottrell precipitators have been used successfully with both small boilers and the very large boilers developed in recent years.

OTHER APPLICATIONS

Cottrell precipitators have wide application in the recovery of other materials such as acid mist, blast furnace dust, sodium salts, fluid catalyst and valuable metals from smelters.

YOU GET all these important advantages PLUS Research Corporation's 38 years of experience in the field of electrical precipitation. Every Cottrell installation is individually engineered to do the most efficient job. For more facts about Research-installed Cottrells, send for Bulletin 500.

RESEARCH CORPORATION

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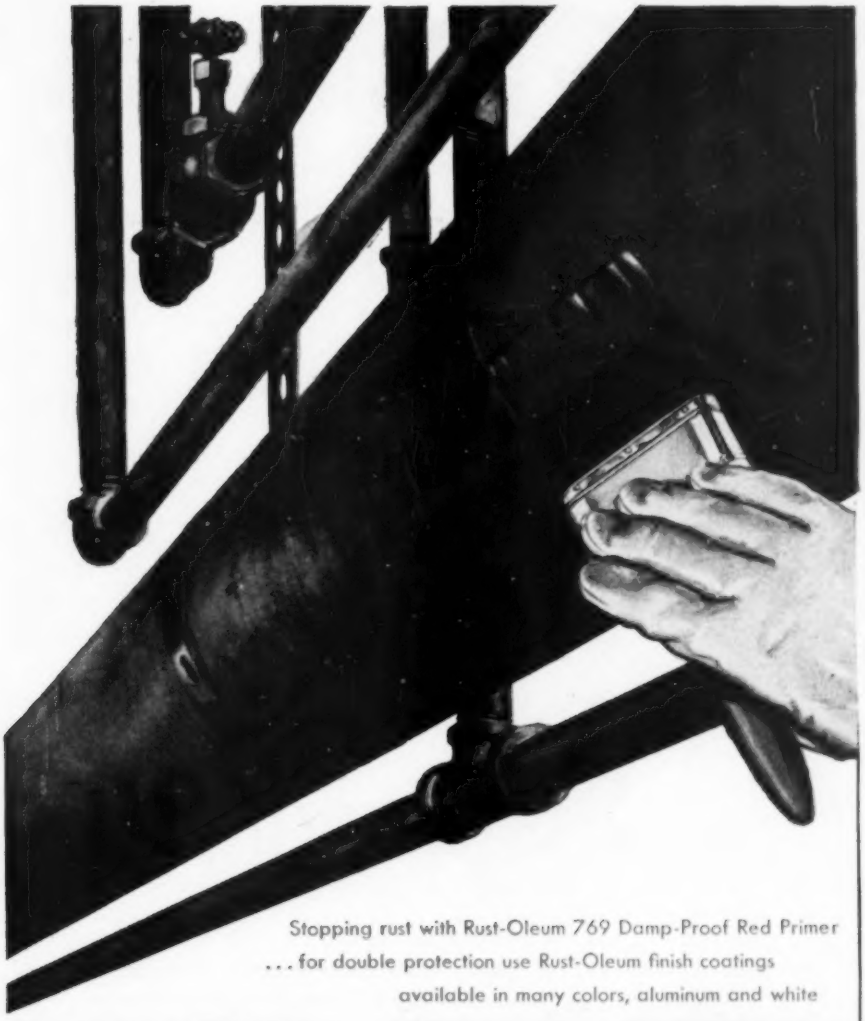
122 South Michigan Avenue, Chicago 3, Illinois



Stopping rust with Rust-Oleum 769 Damp-Proof Red Primer
... for double protection use Rust-Oleum finish coatings
available in many colors, aluminum and white

RUST-OLEUM®

STOPS RUST!

Applied by brush, dip, or spray.

Just scrape and wirebrush to remove rust scale and loose particles . . . then brush Rust-Oleum 769 Damp-Proof Red Primer *directly over the sound rusted surface.* Chemical pre-cleaning and other costly preparations are *not* usually required. Rust-Oleum finish coats in many colors provide *double protection.* Specify Rust-Oleum . . . prompt delivery from Industrial Distributor stocks in principal cities.

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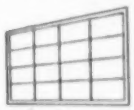
FREE SURVEY: Ask a Rust-Oleum specialist to conduct a survey including actual applications, tests, and recommendations. No cost or obligation. See Sweets for nearest Rust-Oleum distributor or write for literature today.

...proved throughout industry for over 25 years

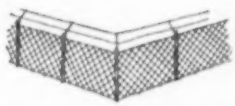
Such fields as Petroleum, Marine, Railroad, Mining, Agricultural, Steel, General Industry are but a few who rely upon Rust-Oleum. General weathering, heat, chemicals, salt water atmosphere, fumes, etc., are only a few of the conditions resisted by Rust-Oleum.

Water tanks, gas tanks, fuel tanks—Rust-Oleum protects your investment.

One truck, or a fleet of trucks, applied over rust, Rust-Oleum keeps them looking better . . . in service longer.



Metal sash and steel windows, roofs, gutters, fire escapes, railings—indoors and out need Rust-Oleum to stop rust.



Wire fence maintenance? Rust-Oleum's Extra-Long Nap Lamb's Wool Roller cuts re-coating costs up to 50% in some cases.

There is Only One Rust-Oleum

Rust-Oleum is an *exclusive formula* developed by a Master Mariner during more than 20 years battling actual rust conditions at sea. It incorporates a *specially-processed* fish oil vehicle that will *dry,* is odor-free, and is formulated in *many* colors. Be sure you specify genuine Rust-Oleum. Accept no substitute.

ATTACH TO YOUR LETTERHEAD—MAIL TODAY!

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- ☐ Have a Qualified Representative Call
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REFINERY has 101 ways to save money

When the yearly cost of replacement parts for 101 steam turbines averages *only 1.6% of the initial investment*, you are saving money . . . and plenty of it.

This amazing record was established by Terry turbines at a large refinery on the Atlantic coast. The percentage figure was determined by means of an accurate tabulation of the cost of replacement parts required over a two-year period.

These 101 Terry machines provide a good cross section of the various types of small and medium-size turbines made by the company. Ranging in size from 10 to 1200 horsepower, they include single and multistage axial flow designs as well as the famous Terry solid-wheel turbine.

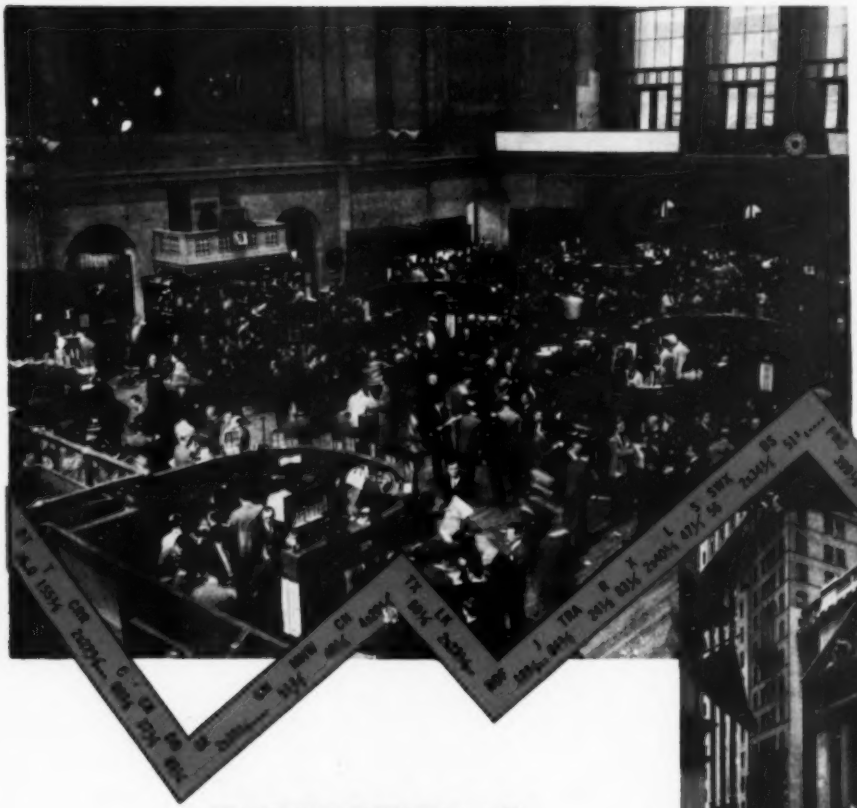
Such outstanding performance records are not at all unusual for Terry turbines. The thousands and thousands of these machines installed in refineries throughout the world provide an accurate yardstick for measuring turbine reliability.

Send for illustrated bulletins. No. S-116 describes the many advantages of the Terry solid-wheel turbine. For multi-stage turbines, ask for a copy of Bulletin S-146.

TERRY

THE TERRY STEAM TURBINE CO.
TERRY SQUARE, HARTFORD 1, CONN.

TT-1194



NEW YORK STOCK EXCHANGE

The Nation's Largest Securities Market Place

BULLS and BEARS all agree on the value of air conditioned comfort

Consulting Engineer present air conditioning system: Charles S. Leopold

POWERS®

AIR CONDITIONING CONTROL

Used in this World Famous Securities Market

No matter how the "temperature" of the market fluctuates, air conditions on the trading floor of the Stock Exchange remain stable throughout the year.

Back in 1903 the New York Stock Exchange pioneered with the installation of a comfort cooling system which Mr. Donald A. Kepler, Chief Engineer describes as follows:

"It was one of the first systems of its kind applied to a large densely populated market place and by far the largest plant devoted primarily to air cooling and dehumidification. No controls were employed in the cooling season but in winter temperature and humidity were automatically controlled by a pneumatic system.

The air conditioning system now in use, the third since 1903, is modern and reflects the progress of air conditioning during the past 50 years."

Other Prominent Users of Powers Control

TORONTO STOCK EXCHANGE • **MIDWEST STOCK EXCHANGE**

When temperature and humidity control problems arise contact Powers nearest office. Our 60 years of experience gained in many important buildings may be helpful to you.

Factory and General Offices: Skokie, Ill.

Mr. D. A. Kepler, Chief Engineer, in the photograph above, reports temperature is held within limits of approximately 1° F. plus or minus.

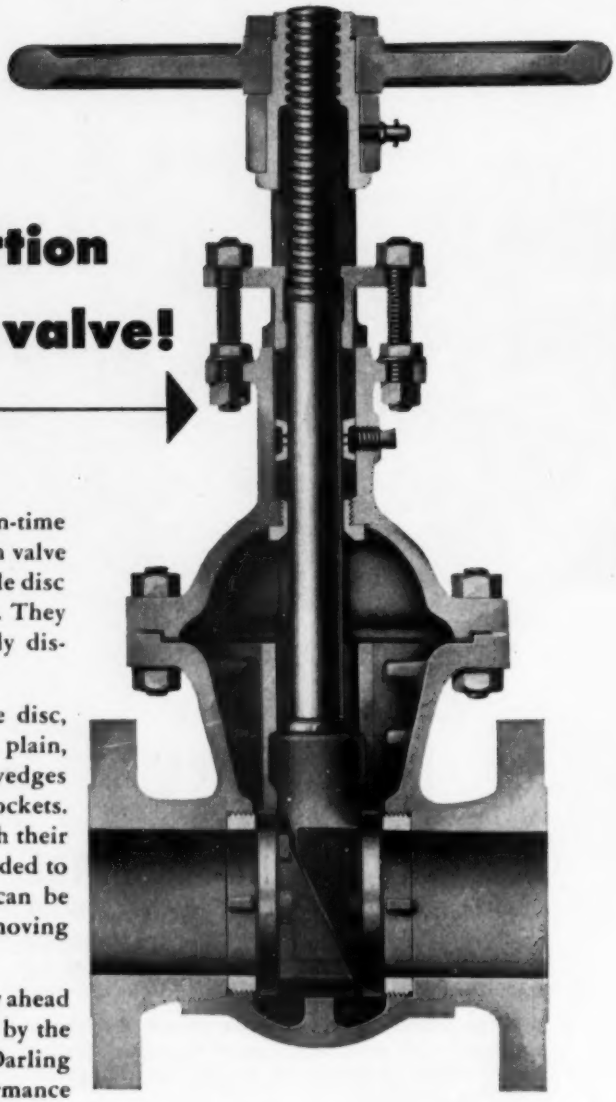
(a94)

OFFICES IN OVER 50 CITIES **THE POWERS REGULATOR COMPANY** Established 1891

DARLING VALVES

FOR PLUS VALUES, JOB-PROVED AGAIN AND AGAIN

Valve body distortion no problem for this valve!



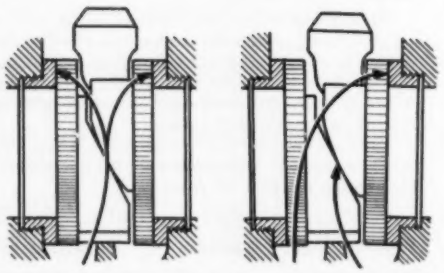
DON'T let costly valve maintenance and down-time headaches get you down! Lick these common valve troubles by installing Darling fully revolving double disc gate valves, with their unique wedging principle. They adjust *automatically* to compensate for valve body distortion—cinching tight, leak-proof closure.

The difference is in the fully revolving double disc, parallel seat principle of Darling valves. Just two plain, interchangeable no-pocket discs and two rugged wedges do all the work. Discs are completely free of pockets. Sediment and scale cannot collect to interfere with their free movement. No links or other devices are needed to hold the discs and wedges together. Any part can be quickly and inexpensively replaced without removing valve from the line.

It's easy to see why Darling valve users are money ahead because of the exceptional service made possible by the Darling design. That's why in plant after plant Darling gate valves are giving longer, trouble-free performance with minimum attention.

Darling features add up to gate valve service at its low-cost best! Send for the free Darling Valve Bulletin, today.

NOTE: Darling gate valves are made in a wide range of sizes, types and constructions, including solid and slotted taper-seat wedge types for all kinds of normal and corrosive services in pressures up to 1500 pounds.



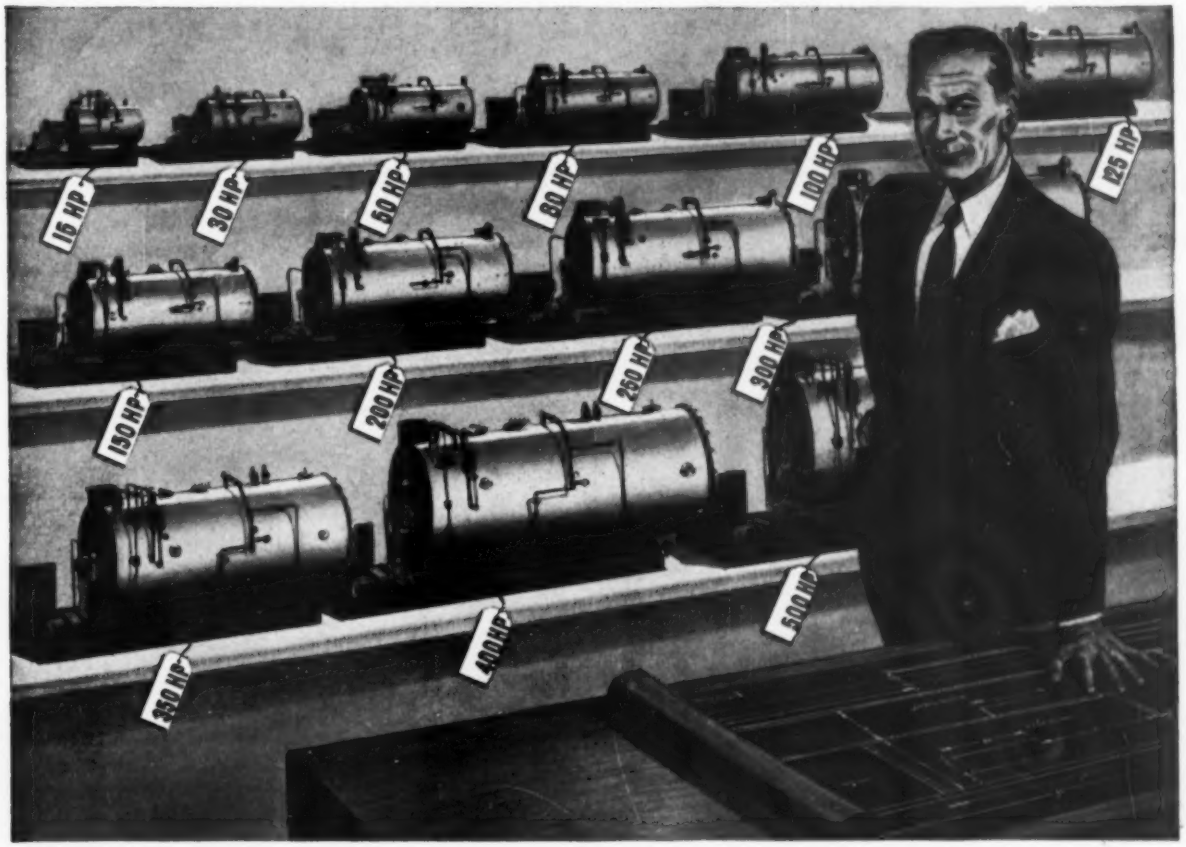
Discs and seats are parallel. *Seats are forced out of parallel by body distortion but discs adapt themselves to give positive closure.* *Radiused face of wedge allows discs to adjust tightly against both seats.*

DARLING VALVE & MANUFACTURING CO.

Williamsport 9, Pa.

Manufactured in Canada by Sandilands Valve Manufacturing Co., Ltd. Galt 19, Ontario

Selecting The Right Boiler Is Most Important...

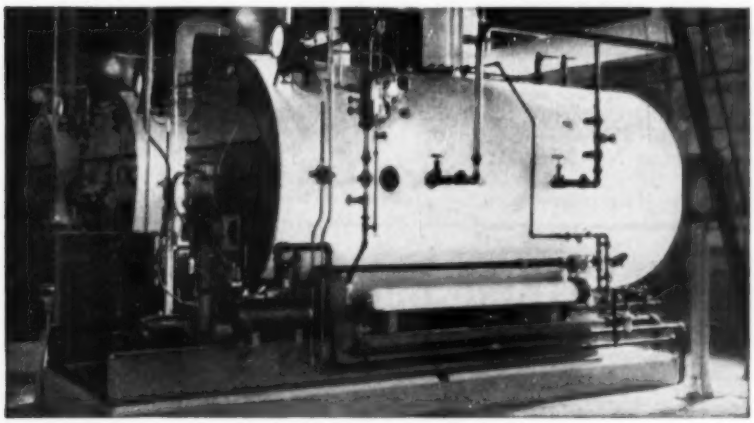


Cleaver-Brooks does not sell steam boilers "off the shelf" even though the boilers are available in standard models. Working with you, your engineers, and your consulting engineers Cleaver-Brooks helps analyze your particular steam needs and loads, both present and future.

These are a few of many factors considered: steam requirements in pounds per hour or b.h.p. — constant or fluctuating loads — fuels available — electric current characteristics — space and boiler room layout — provision for expansion.

Application engineering assistance of this kind assures you a steam plant tailored for your job. Cleaver-Brooks are the first and finest in modern, self-contained steam boilers — operate at a guaranteed efficiency of 80% — burn the fuel most available and economical in your area, gas, oil, or combination gas and oil — fully meet all codes — standard models available in sizes 15 to 500 hp; 15 to 250 p.s.i.

Write for latest, fully illustrated and descriptive Cleaver-Brooks Steam Boiler catalog.



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STEAM BOILERS

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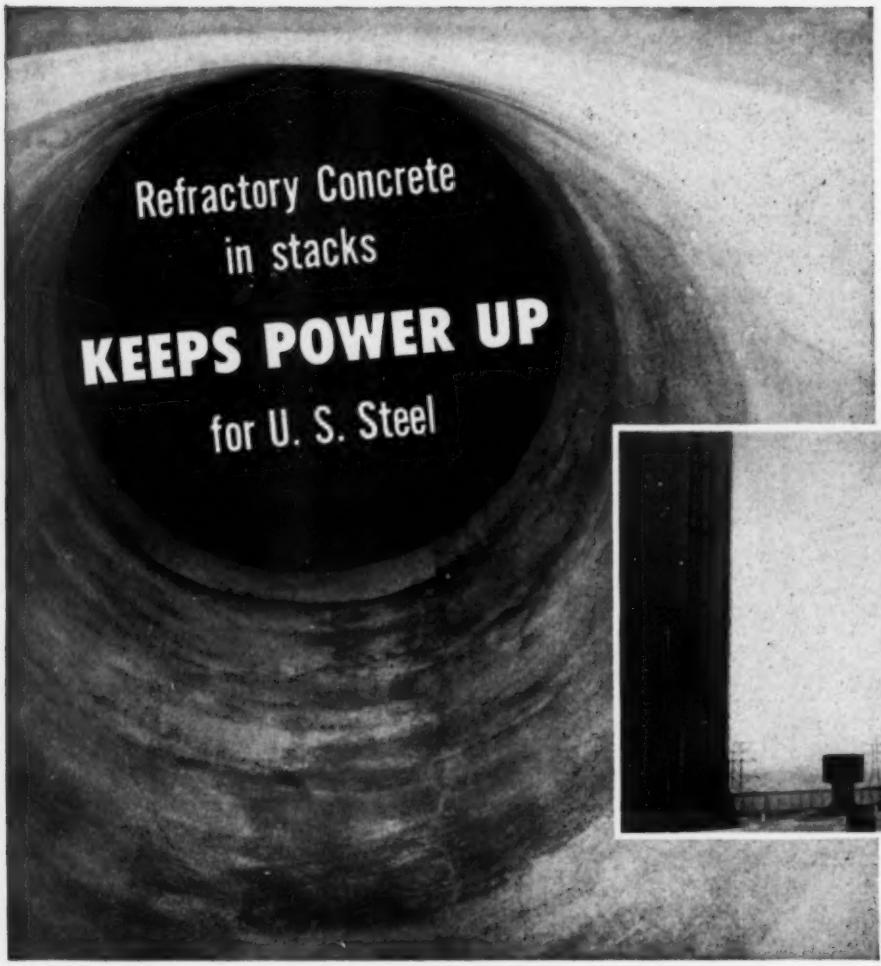
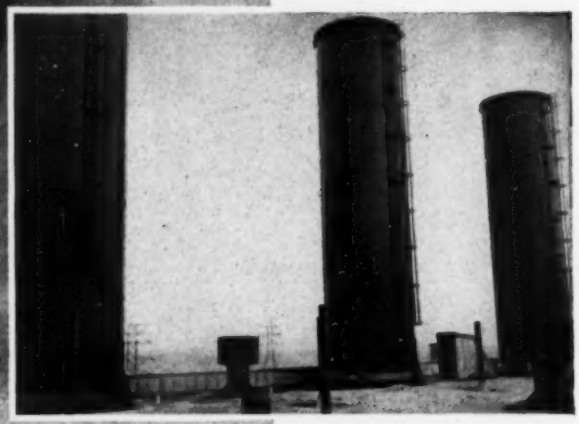
Builders of Equipment for the Generation and Utilization of Heat • Steam Boilers • Oil and Bitumen Tank-Car Heaters • Distillation Equipment • Oil and Gas-Fired Conversion Burners





FAST WORK—Each 14′ 10″ i.d. x 61′ 6″ high stack got a 2½″ lining of Refractory Concrete in just 4 days after reinforcing wire mesh was attached. Concrete made with Lumnite Cement and traprock was "shot" on by cement gun.

You're looking down

the smooth, jointless Refractory Concrete lining that protects a power stack at the new Fairless Works. It's the way U. S. Steel assures long, trouble-free stack life. Here's why:

Saves time. Fast, monolithic construction is further speeded by the ability of Refractory Concrete made with Lumnite* Cement to reach service strength in 24 hours or less! *Helps draft.* The one-piece lining prevents "breathing." *Gives long-lasting protection.* Lumnite-made Refractory Concrete resists attack of sulphurous gas and abrasive fly ash, takes heat to 2600°F, has low volume change and withstands thermal shock.

Whether you're lining or rebuilding a stack, it will pay you to look into the enviable record of Refractory Concrete made with Lumnite calcium-aluminate cement—in power, metals and refining industries . . . in fact, wherever heat, corrosion or abrasion are problems.

FOR CONVENIENCE, you may prefer to make Refractory Concrete with prepared castables (Lumnite Cement plus aggregates selected for specific temperature and insulation service—add only water). They're made by refractory manufacturers and sold through their dealers. For more information, write Universal Atlas Cement Company (United States Steel Corporation Subsidiary), 100 Park Avenue, New York 17, N. Y.

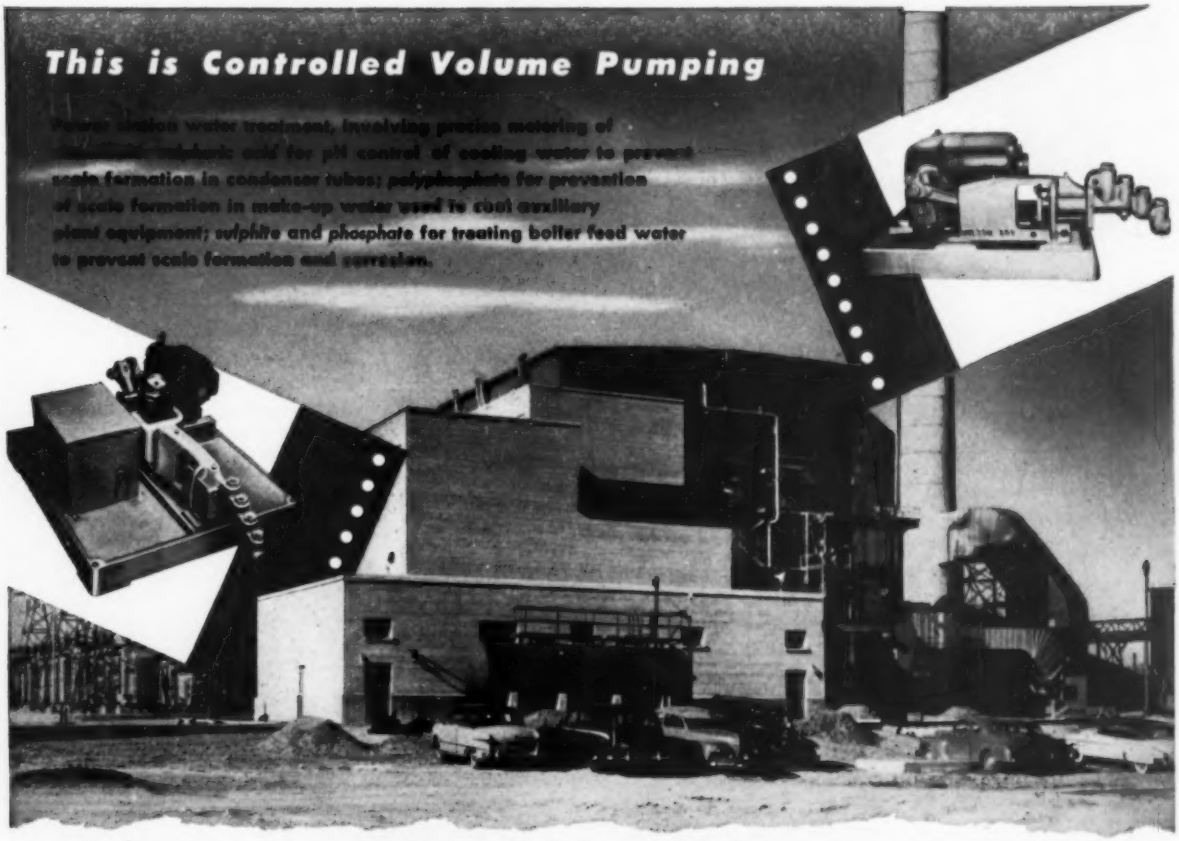
*"LUMNITE" is the registered trade mark of the calcium-aluminate cement manufactured by Universal Atlas Cement Company.

IP-L-74

ATLAS® **LUMNITE for INDUSTRIAL CONCRETES**

REFRACTORY, INSULATING, OVERNIGHT, CORROSION-RESISTANT

"THE THEATRE GUILD ON THE AIR"—*Sponsored by U. S. Steel Subsidiaries—Sunday Evenings—NBC Network*


This is Controlled Volume Pumping
Power station water treatment, involving precise metering of
sulphuric-hydrazoic acid for pH control of cooling water to prevent
scale formation in condenser tubes; polyphosphate for prevention
of scale formation in make-up water used to cool auxiliary
plant equipment; sulphite and phosphate for treating boiler feed water
to prevent scale formation and corrosion.

MILTON ROY CONTROLLED VOLUME PUMPS DO THE JOB . . .

At the Denver, Col., Arapahoe Power Station of the Public Service Company of Colorado, a three-fold water treatment problem is successfully resolved with use of Milton Roy Controlled Volume Pumps.

First, two Milton Roy Motor-Driven Pumps (one in stand-by service) meter 8.7 gph of sulphuric acid into supply water of a closed cycle stable heat system, for pH control to protect condenser tubes against scaling on their inner surfaces. A recording pH control unit automatically adjusts pump capacity by regulation of plunger stroke length. In this process a critical factor is the establishment of a pH balance between maximum scale prevention in the condensers and minimum delignification of a cooling tower structure. Arapahoe engineers report both the elimination of scaling at the condensers and achievement of optimum pH balance.

Scale prevention is also required in make-up water since that water is first used to cool auxiliary equipment of the plant before being injected into the main circulating system. For this purpose, a Milton Roy Simplex Motor-Driven Pump is employed to meter a pre-set volume of polyphosphate into the water at the intake pipe. A similar set-up is used in treating feed water for boilers. Two Milton Roy Simplex Motor-Driven Pumps, arranged in parallel, feed sulphite into the drum for scavenging oxygen. Another pair meters phosphate for prevention of scaling.

Operation of all seven pumps is reported to be reliable and accurate, with no special maintenance problems existing.

Their performance at Arapahoe demonstrates the versatility and dependability of Milton Roy Controlled Volume Pumps. As motor-driven or air-powered units, as components of automatic systems complete with a variety of automatic controls and accessory equipment, these pumps provide the accuracy and dependability so vital to uninterrupted power generation service.

Wherever precise metering of chemicals is required, there's a Milton Roy Controlled Volume Pump to do the job. Milton Roy also supplies systems for all forms of internal and external water treatment, to meet all pressure and capacity requirements. For additional information write us, or get in touch with the Milton Roy representative listed in your classified telephone directory.

Manufacturing Engineers

WITH THE EXCLUSIVE STEP-VALVE DESIGN

MILTON Roy COMPANY

1319 EAST MERMAID LANE, PHILADELPHIA 18, PA.

CONTROLLED VOLUME PUMPS AND AUTOMATIC CHEMICAL FEED SYSTEMS

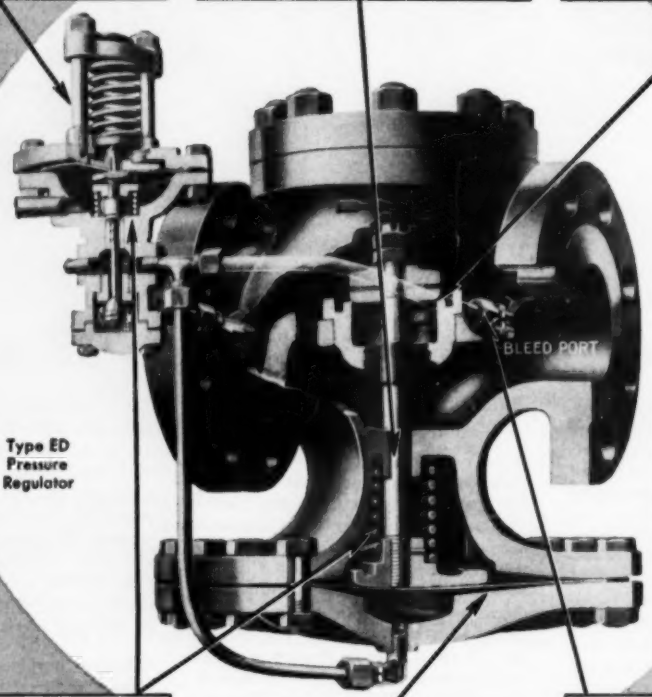
ONLY SPENCE REGULATORS

...give you all these design advantages

Separate Interchangeable Pilot . . .
controls main valve . . . simplifies inspection and maintenance.

Packless Construction . . .
minimizes friction . . . improves control accuracy and eliminates much time-consuming maintenance.

SECO Metal Seats and Discs . . .
resist wiredrawing. More than 20 years of experience has failed to produce a single case where SECO Metal was cut by steam.



Type ED Pressure Regulator

Dead-End Shutoff . . .
guaranteed on steam service when a balanced, single-seated main valve is equipped with SECO Metal seat and disc and is protected by an approved strainer.

Internal Springs . . .
out of path of steam or other fluid flowing through the valve. They operate at low unit stress for exceptionally long life.

Large Balanced Metal Diaphragms . . .
located in a cooled zone with a condensate seal above and below, under usual conditions, never need replacement.

Ease of Inspection . . .
quick access to all vital elements of regulator. No special tools needed.

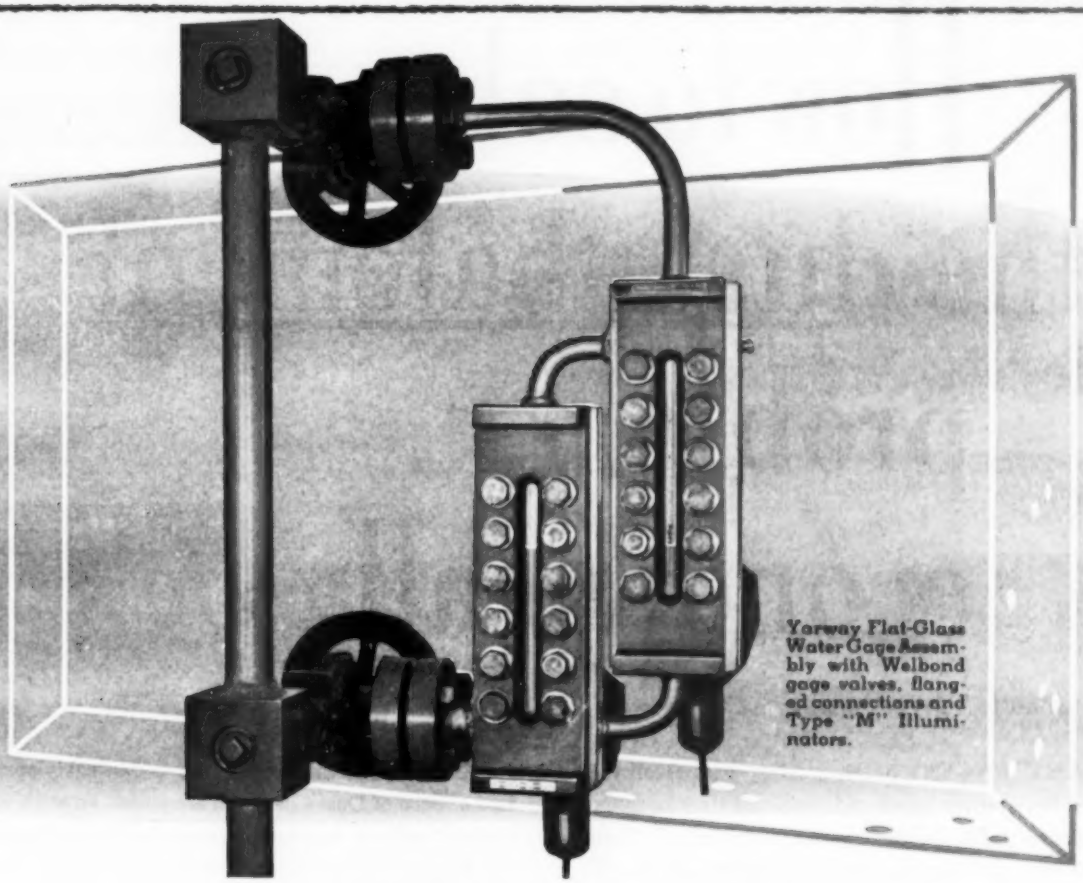
These Spence design features explain why Spence Regulators function dependably and accurately year after year, without requiring extensive repairs or special attention. This lowers over-all costs . . . means less down-time of the system. • Spence makes a complete line of automatic regulating valves: pressure reducing, differential pressure, back pressure control, pump governor, temperature regulating and other types. Write for Bulletin giving full details.

Spence

SPENCE ENGINEERING COMPANY, INC.
WALDEN, NEW YORK

What's New

IN BOILER WATER LEVEL INDICATION?



Yarway Flat-Glass Water Gage Assembly with Welbond gage valves, flanged connections and Type "M" Illuminators.

NEW *SEPARATED-DESIGN* WATER GAGES

This new Yarway water gage assembly has been developed to meet the demands for greater dependability, longer life, and more accurate readings in high pressure service.

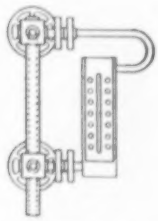
The gage glass inserts are of the Yarway pressure-sealed "floating assembly type". Yarway Welbond gage valves are used. Greater flexibility is gained by using two independent inserts, and by interconnecting expansion loops (see above).

The short connection to the drum assures greater accuracy of the gage reading, and the lower flanged connection eliminates a stuffing box. The upper flanged loop connection between the insert and gage valve allows expansion and contraction of the various components.

The tie bar-type water column linking the gage valves provides circulation to keep gage nearer drum temperature.

Yarway Type "M" Illuminators on the gage inserts cause the meniscus at water level to "shine like a star". This illuminator is especially effective in penetrating deposits on gage glass, dust particles in air and extraneous light.

For full information, write for Yarway Bulletin WG-1811.



Yarway Single Insert type gage for medium range of visibilities.

YARNALL-WARING COMPANY • 109 Mermaid Avenue, Philadelphia 18, Pa.

YARWAY® STEAM PLANT EQUIPMENT

Your Management wants to know...

How to solve the dust abatement problem ... economically

PLANT ENGINEERS, working with Buell engineers, have proven again and again that their know-how coupled with Buell's long experience in Dust Collection can solve your Fly Ash problems more economically, more efficiently.

What's more, Buell Dust Collection Systems offer all American industry these further advantages: smoother plant/community relations, improved product quality and better employee morale.

Buell's knowledge and experience in the highly specialized science of Dust Collection are yours. To learn more about Buell's **3 basic systems** of Dust Collection and how they can help you, send for the new, informative booklet titled, "The Collection and Recovery of Industrial Dusts." Buell Engineering Co., Dept. 90-A, 70 Pine Street, New York 5, N. Y.

VAN TONGEREN CYCLONE

'SF' ELECTRIC PRECIPITATOR

PRECIPITATOR-CYCLONE COMBINATION

TYPE 'LR' COLLECTOR

DUST HOPPER VALVES

ELECTRIC CYCLONIC

buell

ENGINEERED EFFICIENCY IN DUST COLLECTION

Hose by NYB&P

types and constructions for any industrial need

AIR HOSE

MAGIC—An exceptionally flexible portable compressor hose. It is resistant to hot or cold oil in the air line and withstands severe abuse.

STERLING CORD—The finest lightweight, long-length air hose that has ever been built. For general air drill or pneumatic tool work where flexibility and light weight are desirable.

JUBILEE GENERAL PURPOSE—For general utility in pneumatic tool and air drill service. Rayon-braided type with an oil-resistant neoprene tube which will handle satisfactorily almost any fluid.

STEAM HOSE

HY-TEST—It affords positive protection, even under 200 pounds pressure. Its wire-braided plies resist continuous pressures and high temperatures far longer than any other type of hose. HY-TEST WILL NEVER BURST!

GREAT SEAL ASBESTOS CORD—Especially recommended for superheated steam service. Asbestos cords are cushioned in a layer of rubber and wrapped in a heat-resistant rubber cover. A static conducting wire is built in.

INDESTRUCTIBLE—The general all-duty steam hose with an extra degree of dependability and extra-long service life. Thousands of engineers have standardized on Indestructible and have continued to use it year after year for all general steam hose applications. For pressures up to 150 pounds depending on size and number of plies.

OIL and GASOLINE HOSE

NYB&P makes every type of oil and gasoline hose—from delivery and service station hose to dock and sea loading hose. The line incorporates the latest developments in hose design and construction—to give you the utmost in performance and durability.

Be sure to see your NYB&P Distributor for the right engineering advice and recommendations. This is a sure way to get the *right* product for your needs...whether it be hose, belting or packings.

Write for name of Distributor nearest you.

NEW YORK BELTING & PACKING • NYB&P INDUSTRIAL RUBBER PRODUCTS • Since 1846

NEW YORK BELTING & PACKING COMPANY

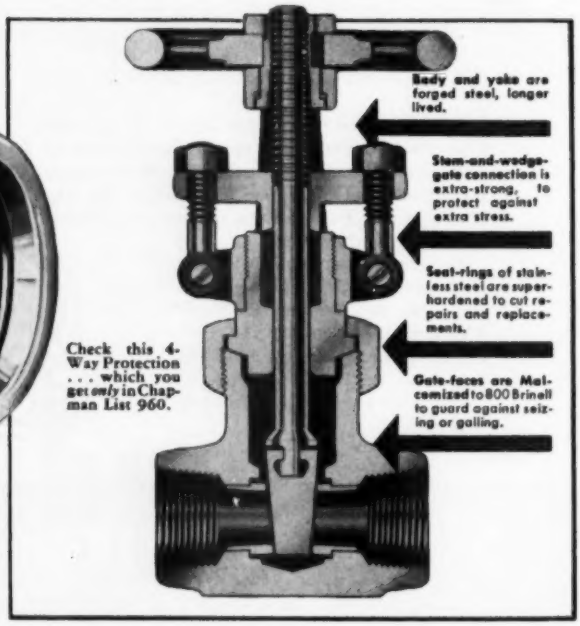
1 MARKET STREET, PASSAIC, NEW JERSEY

If it's for Small Forged Steel Gate Valves . . . then it's for

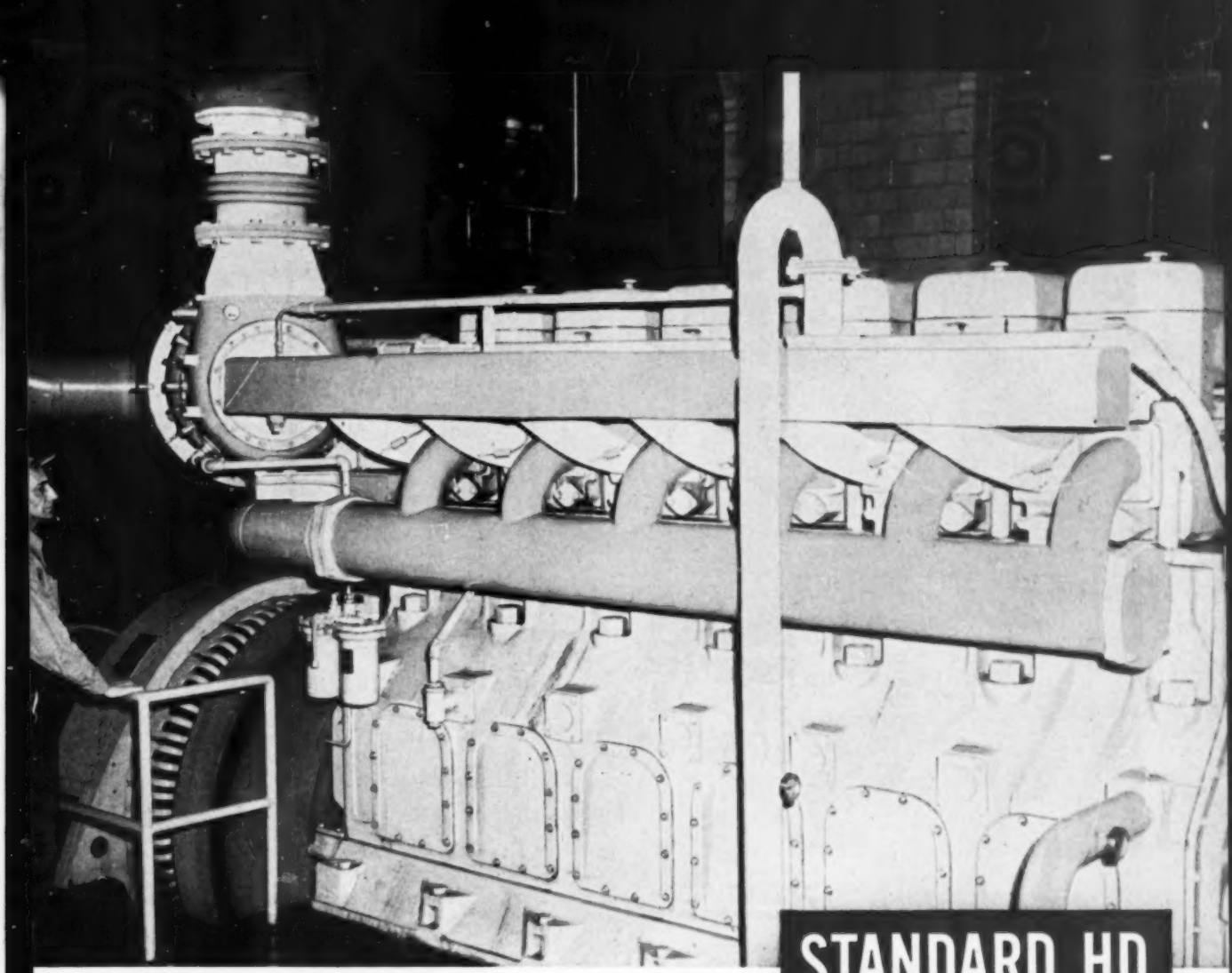
CHAPMAN LIST 960

Many different jobs . . . but on each one, List 960 gives you the same top standard of Chapman Valve performance. Check the 4 exclusive Chapman features below . . . and make this your *check list* in buying *all* forged steel gate valves from ½" to 2" inclusive.

Chapman List 960 is manufactured with rising stem, either with yoke as shown, or with inside screw . . . and with gasketed or metal-to-metal bonnet joints. Pressure range: 2,000 lb. at 100°F. to 380 lbs. at 1,000°F. For higher pressures, specify List 990. Have you a copy of Catalog No. 10? Write for it today.


Body and yoke are forged steel, longer lived.
Stem-and-wedge-gate connection is extra-strong, to protect against extra stress.
Seat-rings of stainless steel are superhardened to cut repairs and replacements.
Gate-faces are Metcomized to 800 Brinell to guard against seizing or galling.
Check this 4-Way Protection . . . which you get only in Chapman List 960.

The **CHAPMAN VALVE**
MANUFACTURING COMPANY
Indian Orchard, Mass.



STANDARD HD
TRADE MARK
OIL

Gets maximum protection with...

● At the time this supercharged diesel engine was installed in a municipal power plant, STANDARD HD Oil had already established an outstanding record for effective lubrication in the plant's other units. In the new unit, STANDARD HD has set a new high for efficient performance.

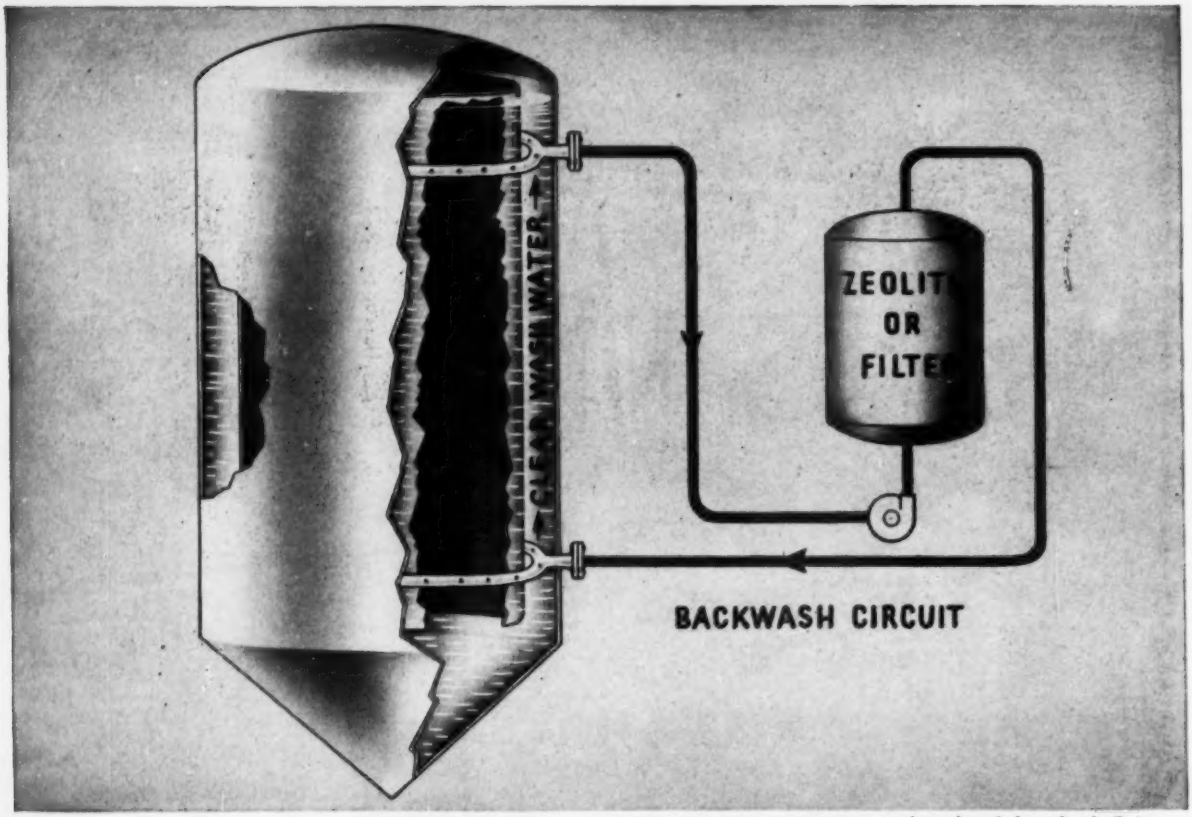
Most of the plant's load has been carried by the new, supercharged unit. In two years of continuous, hard service, STANDARD HD has supplied clean, protective lubrication. There have been no shutdowns for oil system maintenance. The original fill of oil has never been changed and has remained in excellent condition, as shown by periodic tests of oil samples.

The experience of this power plant, and that of a host of midwest diesel operators, indicates the savings you can make with STANDARD HD. The Standard Oil lubrication specialist serving your section of the Midwest will be glad to give you information about the use of STANDARD HD in plants near your own with which you may be familiar. You can contact the lubrication specialist by phoning your local Standard Oil office. Or write: Standard Oil Company, 910 South Michigan Avenue, Chicago 80, Illinois.

STANDARD OIL COMPANY

STANDARD

(Indiana)



BACKWASH FLOW CIRCUIT IN WORTHINGTON HOT-PROCESS SYSTEM shows how *independent* built-in, annular wash-water compartment* provides clean, hot, chemically inert water for backwashing and reclaims it without affecting operating velocities in treating zone, or subjecting hot zeolite to temperature changes. Backwashing is accomplished by recirculation of the clarified wash water.

*Reg. U.S. Pat. Off. 2,263,398

You can't wash clean with dirty water!

How Worthington Hot-Process Water-treating systems backwash with CLEAN, hot, chemically inert water

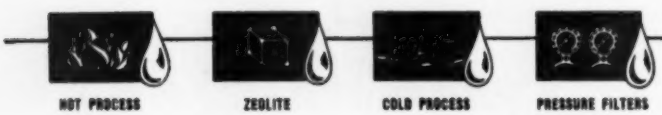
When you're considering hot-process water-treating systems with hot zeolite, filters, or both, *don't overlook backwashing facilities.*

They must be well designed, or the system cannot give smooth, efficient, trouble-free performance. Worthington engineers recognized this fact when they designed their first hot-process system. Today, every Worthington standard Hot-Z or conventional system provides exclusive *independent* facilities for backwashing zeolite or filters with clean, hot, chemically inert water without disturbing the normal flow through the reaction bank.

Worthington water-treating specialists don't believe you can wash clean with dirty water.

This unique backwashing provision is just one of many Worthington patented features, but it alone will more than justify your selection of a Worthington system for hot-processing boiler feedwater in your plant.

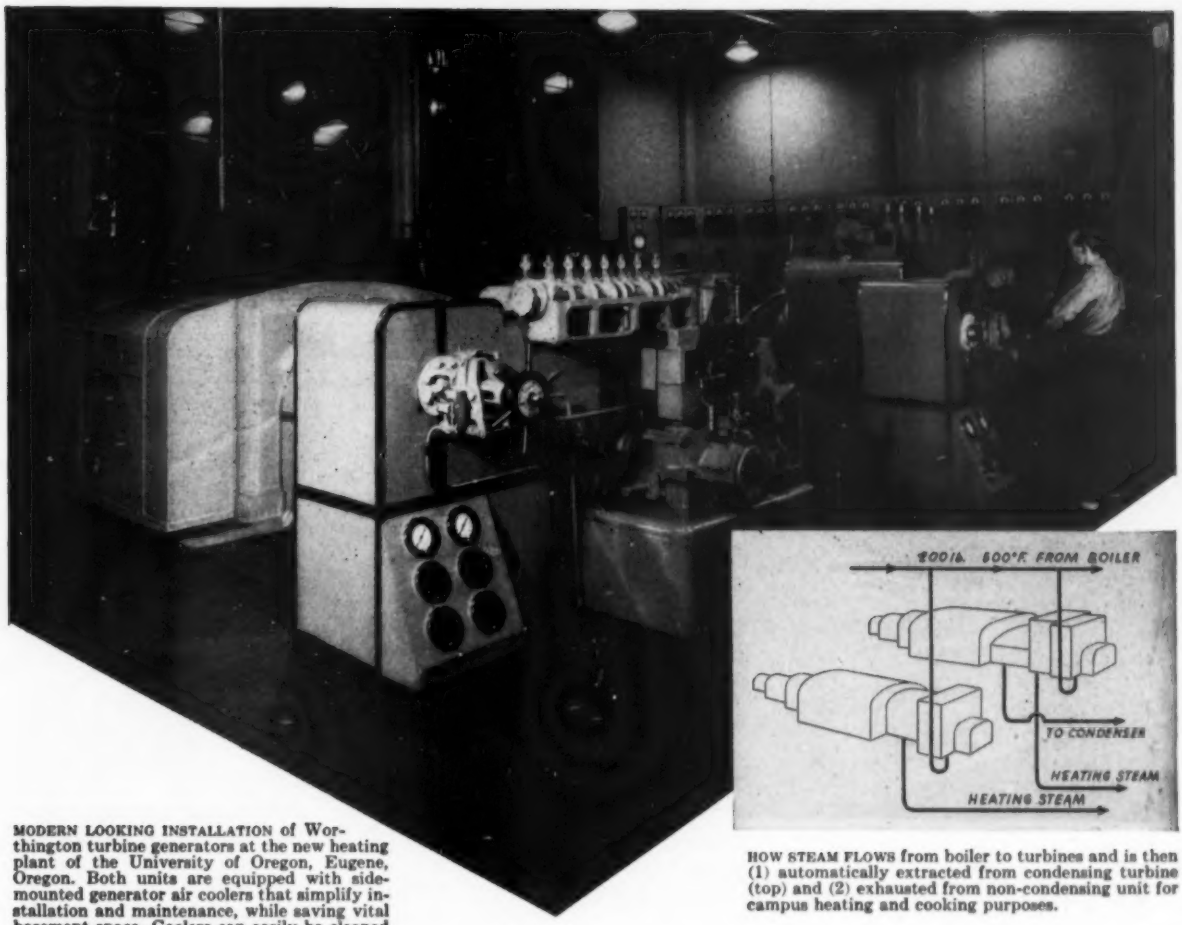
If you have a problem, whether it involves filtration, precipitation, or zeolite treatment, Worthington specialists will be happy to study your water-treating problem and recommend the proper system. Just write, stating service conditions in detail, to Worthington Corporation, Water Treating Division, Harrison, N. J. J-2.1



Worthington Makes More of the Equipment for ALL Types of Water Conditioning Systems

WORTHINGTON

Water Conditioning



MODERN LOOKING INSTALLATION of Worthington turbine generators at the new heating plant of the University of Oregon, Eugene, Oregon. Both units are equipped with side-mounted generator air coolers that simplify installation and maintenance, while saving vital basement space. Coolers can easily be cleaned during turbine operation.

HOW STEAM FLOWS from boiler to turbines and is then (1) automatically extracted from condensing turbine (top) and (2) exhausted from non-condensing unit for campus heating and cooking purposes.

Worthington turbine generators at U. of Oregon designed for operating flexibility and appearance

When the University of Oregon built the new heating plant in 1951, the plans included installation of two turbine generators which would supply all the school's present and anticipated electrical and steam requirements.

But the university had another requirement—one not uncommon these days—that the installation be as clean and as modern looking as possible. One look at the above photograph and flow diagram shows that they got both in the Worthington turbine generators now in operation at the plant.

In the installation of Worthington turbine generators, the University of Oregon was assured of low-cost power and steam. It was also assured of the undivided responsibility that goes with turbine generators, designed, engineered, assembled and tested as complete units before shipment.

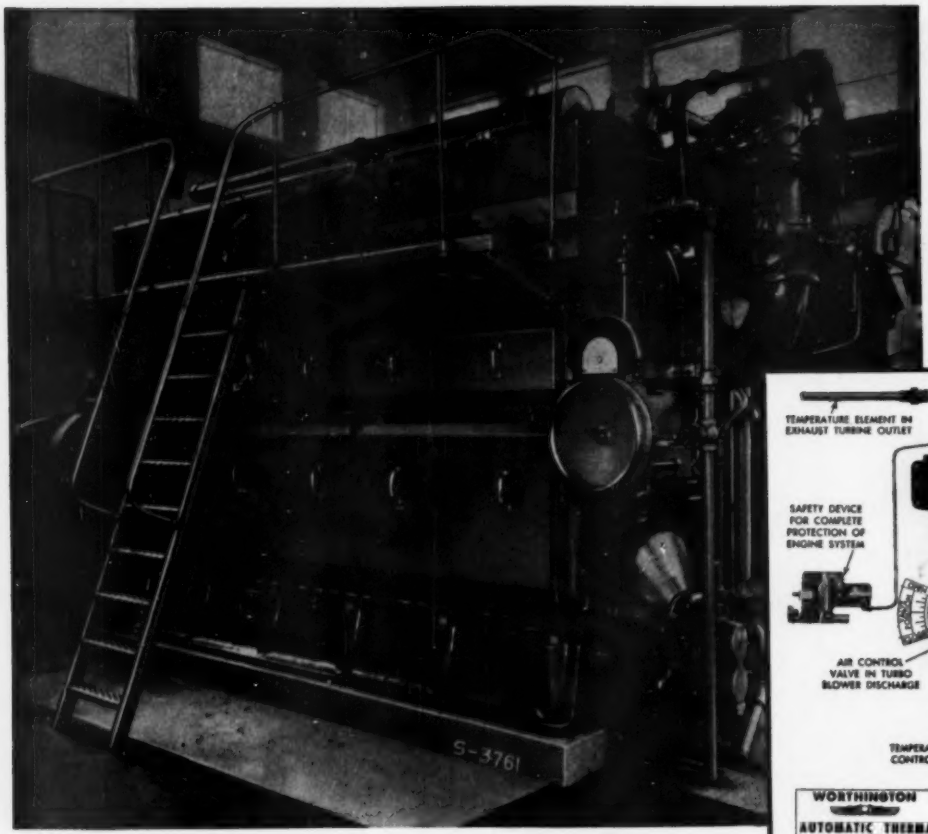
Sizes to 10,000 kw. Worthington Corporation, Steam Turbine Division, Wellsville, New York.

T-2-10

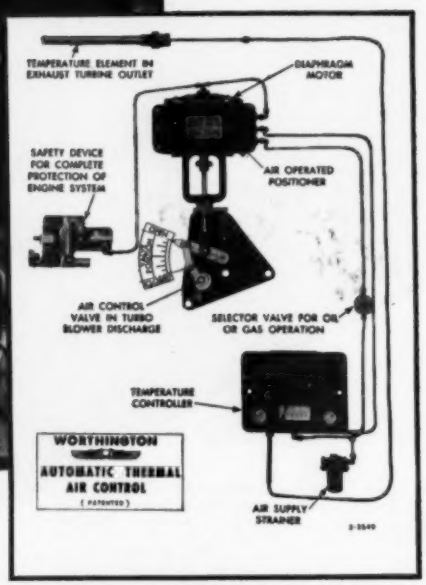
A GREAT TEAM IN STEAM

WORTHINGTON

Steam Turbine Generators



HANDLING INCREASING LOADS at the Vermillion, S. D., municipal power plant is this Worthington converted 840-kw dual fuel Diesel engine.


TEMPERATURE ELEMENT IN EXHAUST TURBINE OUTLET
DIAPHRAGM MOTOR
SAFETY DEVICE FOR COMPLETE PROTECTION OF ENGINE SYSTEM
AIR OPERATED POSITIONER
AIR CONTROL VALVE IN TURBO BLOWER DISCHARGE
SELECTOR VALVE FOR OIL OR GAS OPERATION
TEMPERATURE CONTROLLER
WORTHINGTON
AUTOMATIC THERMAL AIR CONTROL
(PATENTED)
AIR SUPPLY STRAINER

WORTHINGTON AUTOMATIC THERMAL AIR CONTROL supplies correct air-fuel ratio to the engine cylinders *at all times* and *in direct relation to all load changes.*

Vermillion, South Dakota, meets new power demands

In 1949, the City of Vermillion, South Dakota, was faced with the necessity of meeting increased electrical load requirements on its municipal power plant.

To solve this problem, Vermillion plant engineers decided to have their Worthington EE-6 Diesel engine, installed in 1937, converted to a more powerful unit.

Worthington engineered the change-over of the 500-kw naturally aspirated oil Diesel to an 840-kw supercharged dual fuel Diesel—an increase of 340 kw. Engine speed was raised from 327 to 360 rpm.

Now, after a year and a half of heavy-duty operation, the Worthington converted engine has proved to be the most efficient and reliable power producer in the Vermillion plant.

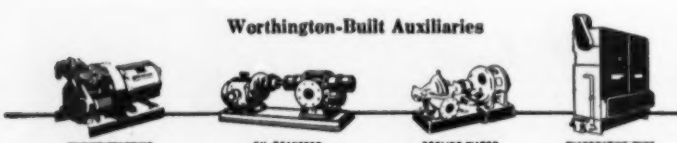
Four of the many exclusive Worthington features that insure top performance of Worthington dual fuel engines are:

1. Worthington automatic thermal air control for improved fuel economy.
2. Worthington dual plunger fuel pump for better, quieter combustion.
3. Worthington micro-metering gas valves—one for each cylinder—for equal cylinder loading and better speed regulation.
4. Worthington helical steel gear train for accurate and positive control of engine timing.

Worthington Corporation, Engine Division, Buffalo, New York.

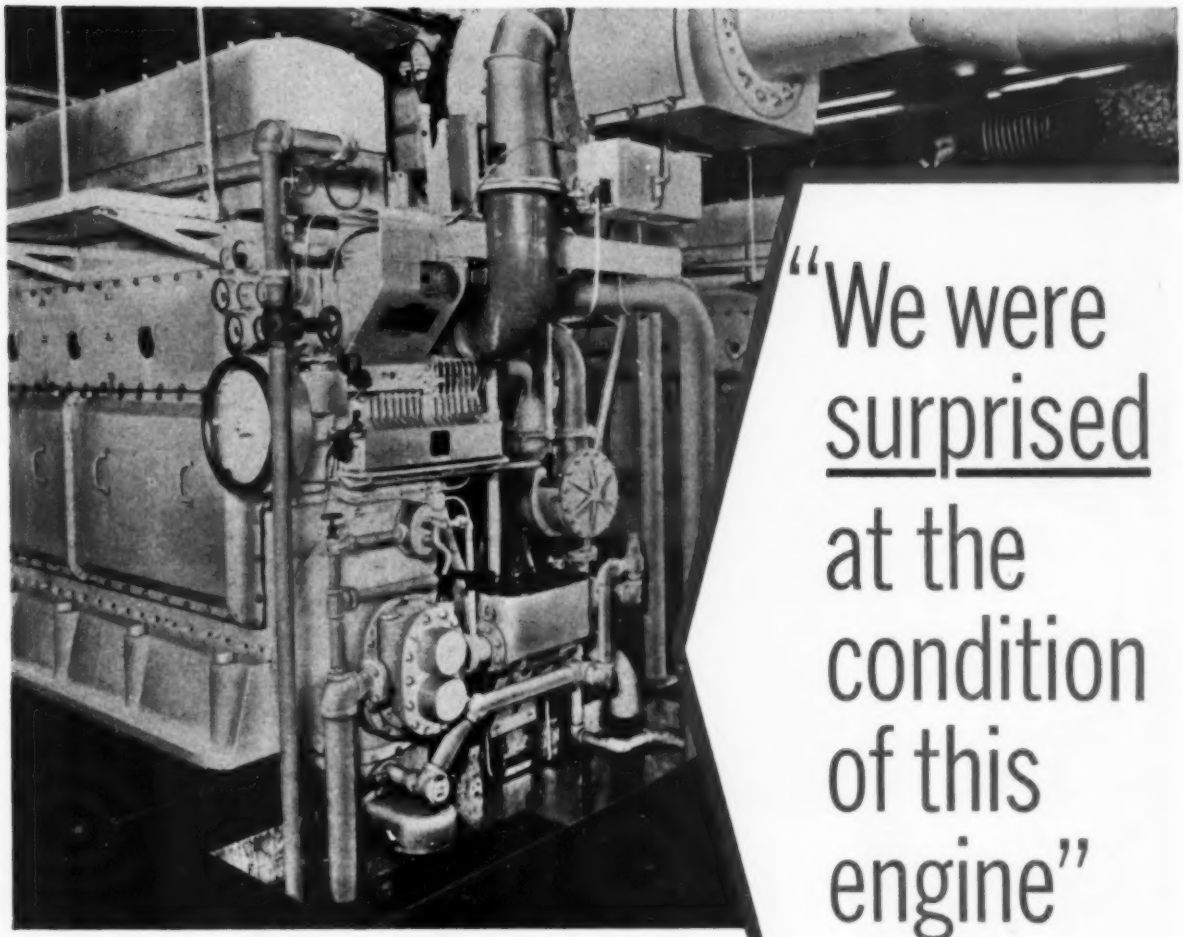
E-2.5

Worthington-Built Auxiliaries



Economical Continuous Power—Diesels, Oil and Dual Fuel, and Spark-Ignition Gas Engines, from 150 to 2100 bhp.

WORTHINGTON
Engines



"We were surprised at the condition of this engine"

... says G. V. Yarger,
Supt. Municipal Utilities
Waverly, Iowa

"When we finally opened up our Worthington, it was in the *best* condition I've ever seen a diesel engine that had operated such long hours and under such heavy loads as this unit. It had a total of 48,926 hours on it – 8,987 hours of tough operation since the last overhaul.

Mr. Yarger continues, "We've been using Sinclair RUBILENE® Heavy in the crankcase and RUBILENE H.D. 30 in the cylinder lubricator. These RUBILENES have kept the crankcase and upper portions of the cylinders exceptionally clean and bright, with no sign of carbon or deposits."

That's a typical report on the exceptional qualities of the Sinclair RUBILENES . . . evidence that they could improve the efficiency of *your* diesels, too. Why not switch now? Contact your nearest Sinclair Representative or write Sinclair Refining Company, 600 Fifth Avenue, New York 20, N. Y.

SINCLAIR DIESEL OILS

save wear and replacements

A Big Help

on small—as well as big—deaeration jobs

Small deaerators are big business at Worthington! That's why the plant with small-capacity requirements will benefit by getting acquainted with the complete range of Worthington deaerating equipment.

Worthington Gives You All Types, All Sizes

Worthington deaerating heaters and deaerators are built in sizes to handle from a few thousand pounds an hour to over a million. They are tailor-made to fit the particular requirements of each job. Special designs are available for operation with scale-forming water.

Both tray and steam-jet types are made—with external surface-type vent condensers or internal direct-contact vent condensing. They can be furnished for any practical operating pressure—constant or variable—or for vacuum operation.

With a complete range of sizes and types at their fingertips, Worthington engineers can competently recommend the design best suited to *your* requirements.

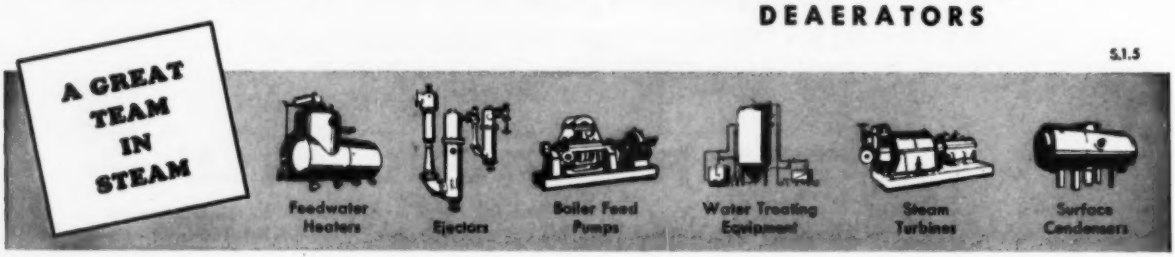
Remember, too, Worthington designs are backed by over 50 years experience in the design and manufacture of direct contact feedwater heaters and over 100 years experience in hydraulic machinery.

Send your water treating problem to Worthington Corporation, Steam Power Division, Harrison, N. J.

WORTHINGTON

DEAERATORS

S.1.5



ADJUSTABLE PIPE HANGERS AND SUPPORTS

for every piping requirement

NO. 1 OF A SERIES SHOWING THE GRINNELL LINE

Malleable iron rings for fire protection, plumbing and heating up to 450°

fig. 104
swivel ring
split ring type
¾" to 8" pipe

fig. 101
swivel ring
solid ring type
¾" to 8" pipe

fig. 101B
swivel ring
with boss
solid ring type
(optional)
2" to 8" pipe

fig. 150
swivel ring
solid ring type
¾" to 8" pipe

fig. 97
wrought ring
malleable nut
½" to 8" pipe

fig. 95
wrought ring
flattened end bolt
½" to 8" pipe

fig. 108
split ring
(ring only)
½" to 8" pipe

fig. 107
split ring
with socket
½" to 8" pipe

fig. 115
split ring
with turnbuckle
adjuster (optional)
½" to 6" pipe

fig. 138
extension ring
tapped I. P. S.
⅜" to 3" pipe

fig. 105
clip ring
¾" to 2" pipe

fig. 232
pear shape ring
½" to 6" pipe

steel clamps for high temperature process and power plant service

fig. 224
forged alloy clamp
4" to 16" pipe

fig. 212
wrought clamp
1½" to 24" pipe
(heavy duty, fig. 216
3" to 16" pipe)

fig. 295
wrought clamp
double-bolt
1½" to 24" pipe

fig. 261
riser clamp
¾" to 20" pipe

fig. 260
wrought clevis
¾" to 16" pipe

fig. 269
wrought band
¾" to 8" pipe

Write for Hanger Catalog

GRINNELL

WHENEVER PIPING IS INVOLVED

Grinnell Company, Inc., Providence, Rhode Island • Coast-to-Coast Network of Branch Warehouses and Distributors

Manufacturer of: pipe fittings • welding fittings • forged steel flanges • steel nipples • engineered pipe hangers and supports Thermolier unit heaters • Grinnell-Saunders diaphragm valves • prefabricated piping • Grinnell automatic fire protection systems

Because you use *the same* **"ECONOMY** *De-Lay"* Cartridge over and over again.

You renew a "blown" **ECONOMY** *Fuse* by simply inserting an inexpensive "ECONOMY DE-LAY" *Renewal Fuse Link* in the old Cartridge.

You reduce "lights out" and "machine down time" because **"ECONOMY** *De-Lay" Fuse Links* are replaced in a few seconds.

Your investment in **"ECONOMY** *De-Lay" Fuse Links is much smaller than the investment required* if you use non-Renewable Fuses for each fuse replacement.

Ask for the ECONOMY *Catalog and Price List.*

DH11

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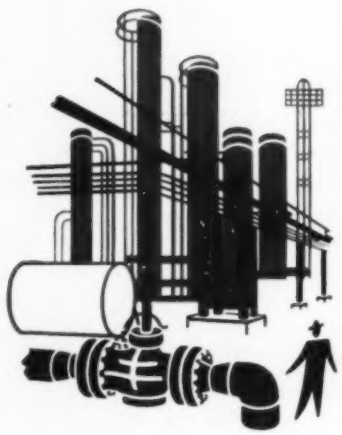
Your Electrical Wholesaler has "ECONOMY DE-LAY" Renewable Fuses and Renewal Links in stock.

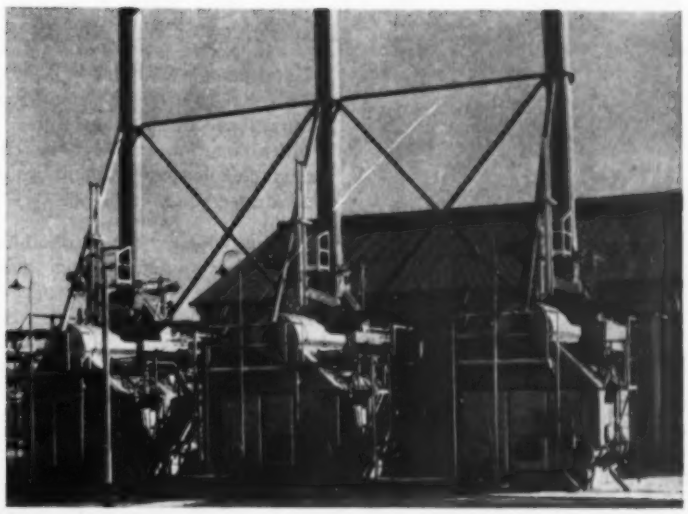
ECONOMY FUSE AND MFG. CO., 2717 GREENVIEW AVE., CHICAGO 14, ILLINOIS REPRESENTATIVES IN ALL PRINCIPAL CITIES

WICKES*

*WICKES steam generators are cutting costs in America's finest refineries and natural gasoline plants



Recognized Quality
Since 1854



Wickes Type A Steam Generators have a splendid record in the oil processing industry. In scores of refineries and natural gasoline plants they have helped speed production and reduce operating costs considerably. They operate at a high degree of efficiency and maintenance costs are unusually low. Wickes can fill your requirements for all types of multiple drum boilers up to 250,000 lbs. steam per hour at 1000 psi. — adaptable to any standard method of firing. Units capable of sustained steam production up to 35,000 lbs. per hour at 1000 psi. can be shop-assembled for immediate installation. Write today for descriptive literature or consult your nearest Wickes representative.

THE WICKES BOILER CO.

SAGINAW, MICHIGAN

DIVISION OF THE WICKES CORPORATION

SALES OFFICES: Atlanta • Boston • Buffalo • Chicago • Cincinnati • Cleveland Denver • Detroit • Greensboro, N. C. • Houston • Indianapolis • Los Angeles Memphis • Milwaukee • New York City • Pittsburgh • Portland, Ore. • Saginaw San Francisco • Springfield, Ill. • Tampa, Fla. • Tulsa • Washington, D. C.

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CONCENTROL STOPS FOAMING

BEFORE

Laboratory demonstration shows foaming of highly alkaline solution in test cylinder.

This laboratory demonstration shows — as do scores of successful installations — that Bird-Archer's Concentrol is a highly effective anti-foam agent. It quickly stabilizes alkaline boiler water . . . eliminates foaming action and carryover. With Concentrol, you can forget about bouncing water gages. You get good quality dry steam every hour of every day.

Concentrol is available in liquid, powdered or briquette forms. Special Concentrol formulations are also available containing other commonly used boiler water treatment chemicals such as tannins, phosphates, alkalies, sulfite, etc.

See for yourself how economical Concentrol helps improve steam quality. Your Bird-Archer representative will demonstrate Concentrol in your plant . . . make specific recommendations for its use. Consult him, or write direct to Bird-Archer, outlining the details of your boiler operation.

FREE DATA SHEET AVAILABLE

HOW CONCENTROL WORKS

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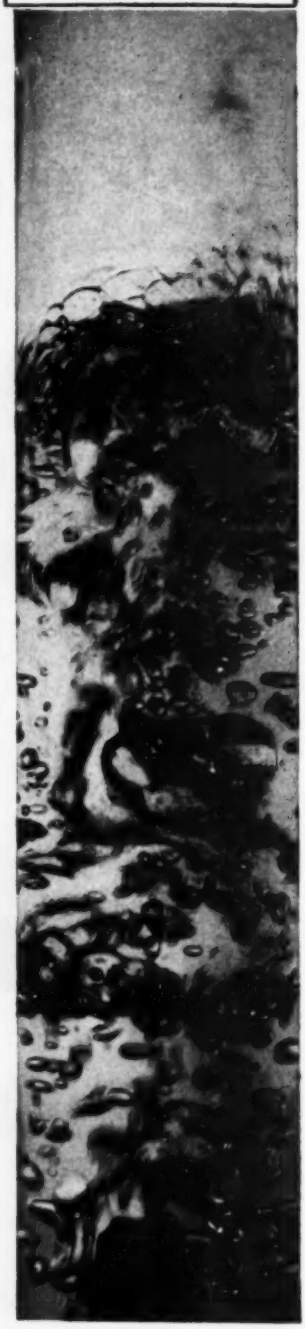

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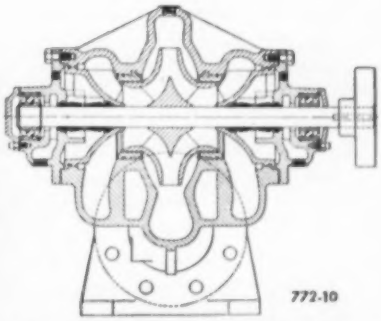

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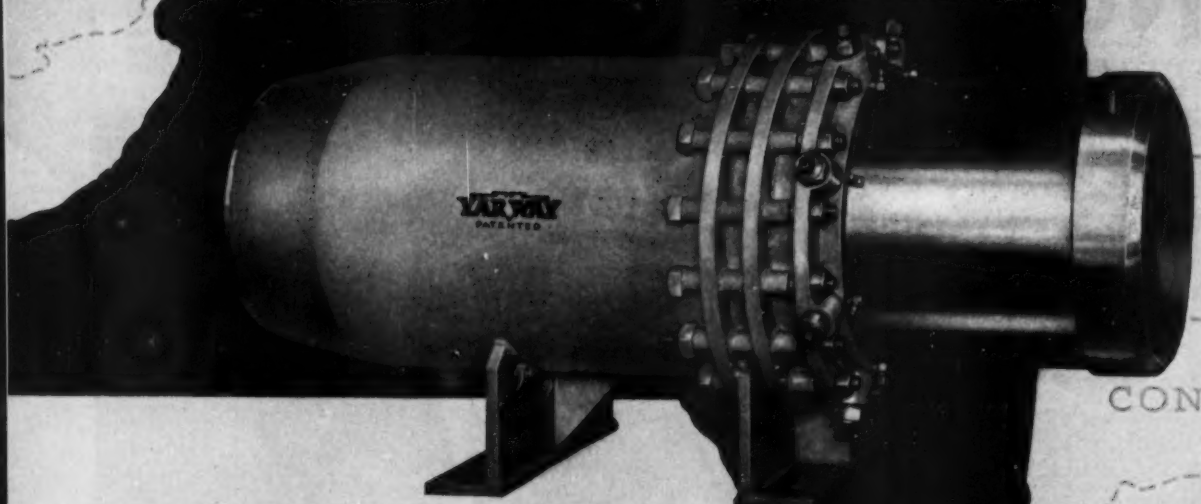

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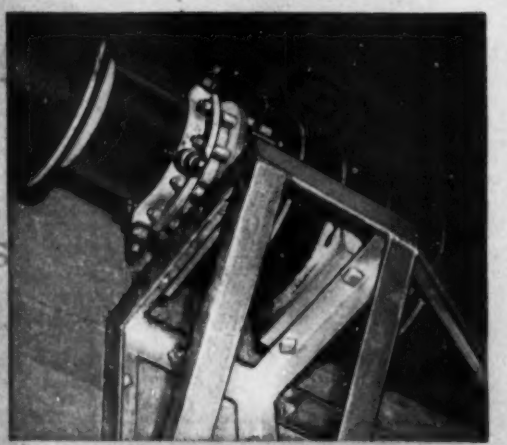

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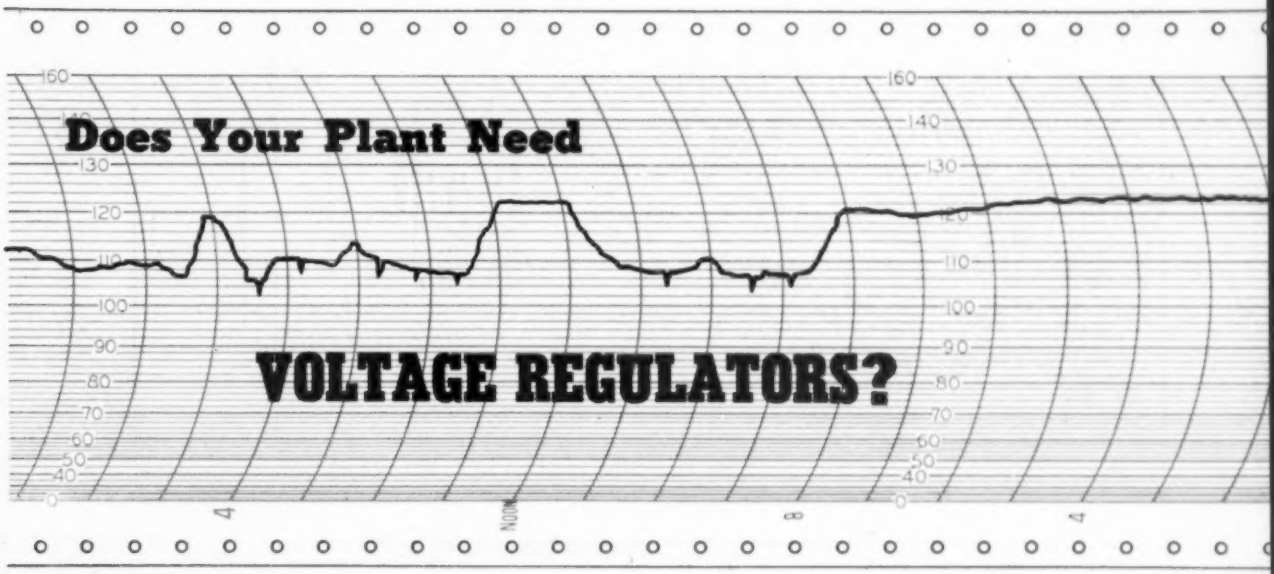


Regulators are necessary in a few cases, advisable in many others. But they should not be used to correct deficiencies in the electrical system without adequate reason. Here is a discussion on the sources of voltage variations, examples of effects on various loads and a brief resume of common types of regulators, the size ranges, characteristics and their relation to the load.

A. B. WHITE, *Associate Editor*

THE PURPOSE of regulators is to hold voltage within very narrow limits at a given point on the electrical system or to greatly reduce variations at circuit points on the load side. Truly constant voltage is seldom necessary and fluctuations can be reduced by other methods. The problem therefore becomes an analysis of requirements and a comparison of economics of the various methods, as well as a balance of the lowest cost against need for better voltage control.

The comparison of methods and costs could evolve into a major project. The purpose of this article is to break a survey of the system into its component parts and to help analyze results that may be obtained from the various methods of correction. Problems involved in a preliminary survey are discussed in order to focus attention on the most important decisions, whether they be to provide spot regulation for individual areas or loads, or to proceed with design of a more adequate system.

In most discussions on voltage regulation, automatic regulators are considered as a makeshift method of obtaining a substantially constant voltage. The consensus seems to be that an adequate modern distribution system will provide a utilization voltage constant within limits suitable for most equipment used in production and in the plant services at the lowest possible operating cost. Certainly this has been proved true in the majority of cases, and nothing in this article should be interpreted to mean that voltage regulators should be substituted for investment in a suitable distribution system.

Excessive voltage variations in a system are normally accompanied by excessive losses. Since a regulator can only change the voltage, the losses will remain and ordinarily, in an inadequate system, their cumulative cost will pay for a new system in a short time.

Partly for this reason, there are few comprehensive studies based on experience* in use of regulators. The first and greatest effort, rightly, has been to improve the distribution system. As a result, applications for regulators are usually individual case studies difficult to reduce to a general recommendation. Furthermore, these studies, as will be shown, often involve economic and human factors not necessarily directly related to operation of the distribution system.

There is a small but widespread minority of applications where voltage

*INDUSTRY AND POWER will welcome correspondence describing your own experience, voltage conditions in your plant, type of loads involved, and your opinion on corrective methods.

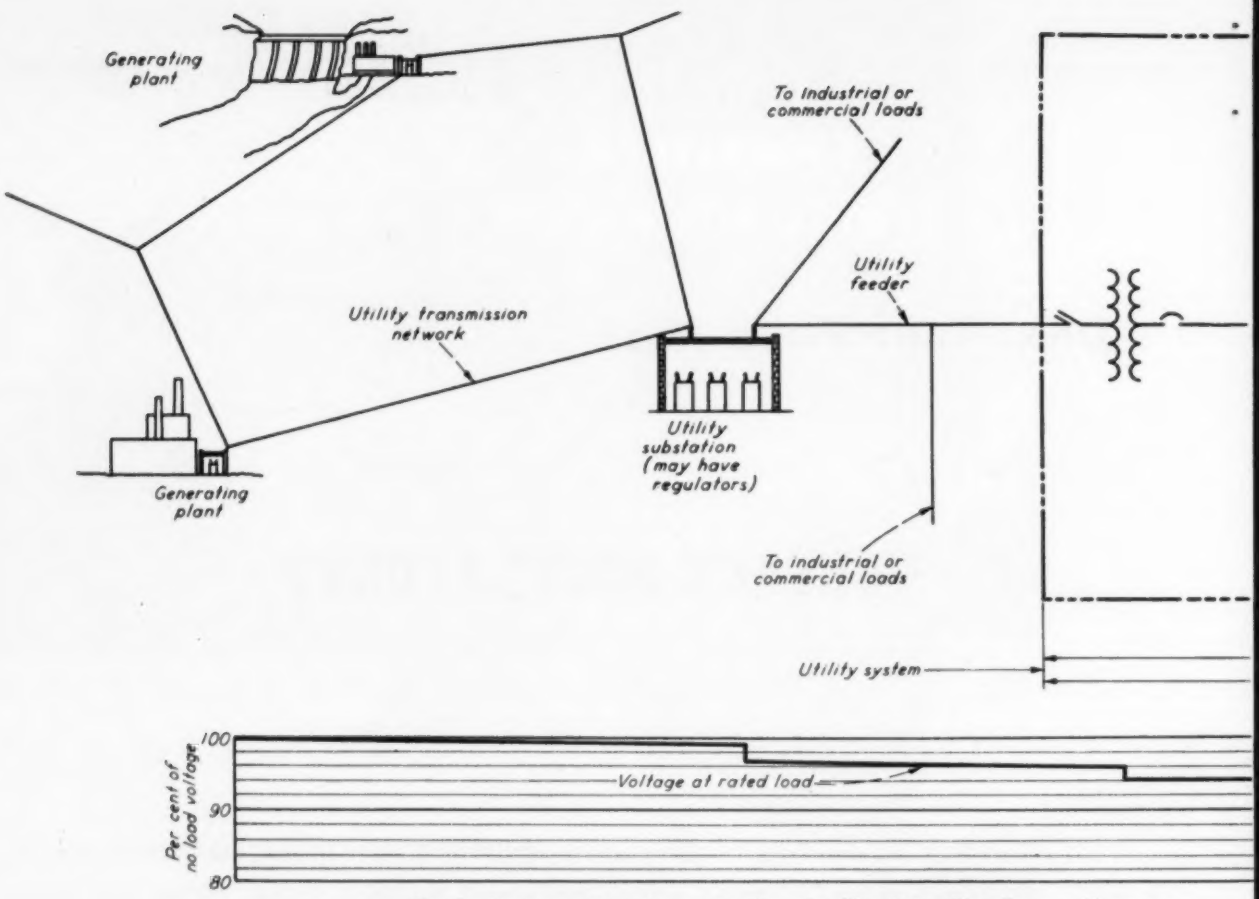


Fig. 1—Plant systems are an extension of utility lines. The diagram illustrates typical sources of full load voltage drops which accumulate to produce total load voltage variation. The gradual line drops vary with size and length of lines; the sharp transformer drops, with voltage class. Actual regulation at load

regulators have been or should be considered. In general, they are created by factors listed in Table 1, page 67, or a combination thereof.

Any system has voltage variations except at the actual point of correction, if any. Variations result from voltage drop inherent in all distribution equipment, whether it be in the industrial plant or the utility supply.

Even in an ideal system there is an appreciable amount of drop, or variation with load, for its value is an economic compromise between good results for the *average* type of utilization equipment and the cost of distribution equipment. Further reductions in voltage drop would not only require more capacity in transformers and cables and/or higher voltages but would also increase switchgear costs to provide the necessary interrupting capacity.

Limits of Voltage Variation

Unfortunately, a range of variation suitable to most situations may be excessive in others. In addition, variations unless corrected at an intermediate point, are cumulative all the way from the source to the load, Fig. 1. Also, fluctuations caused by all other loads on a system are compounded with those caused by the load in question, Fig. 2.

COMMON FACTORS

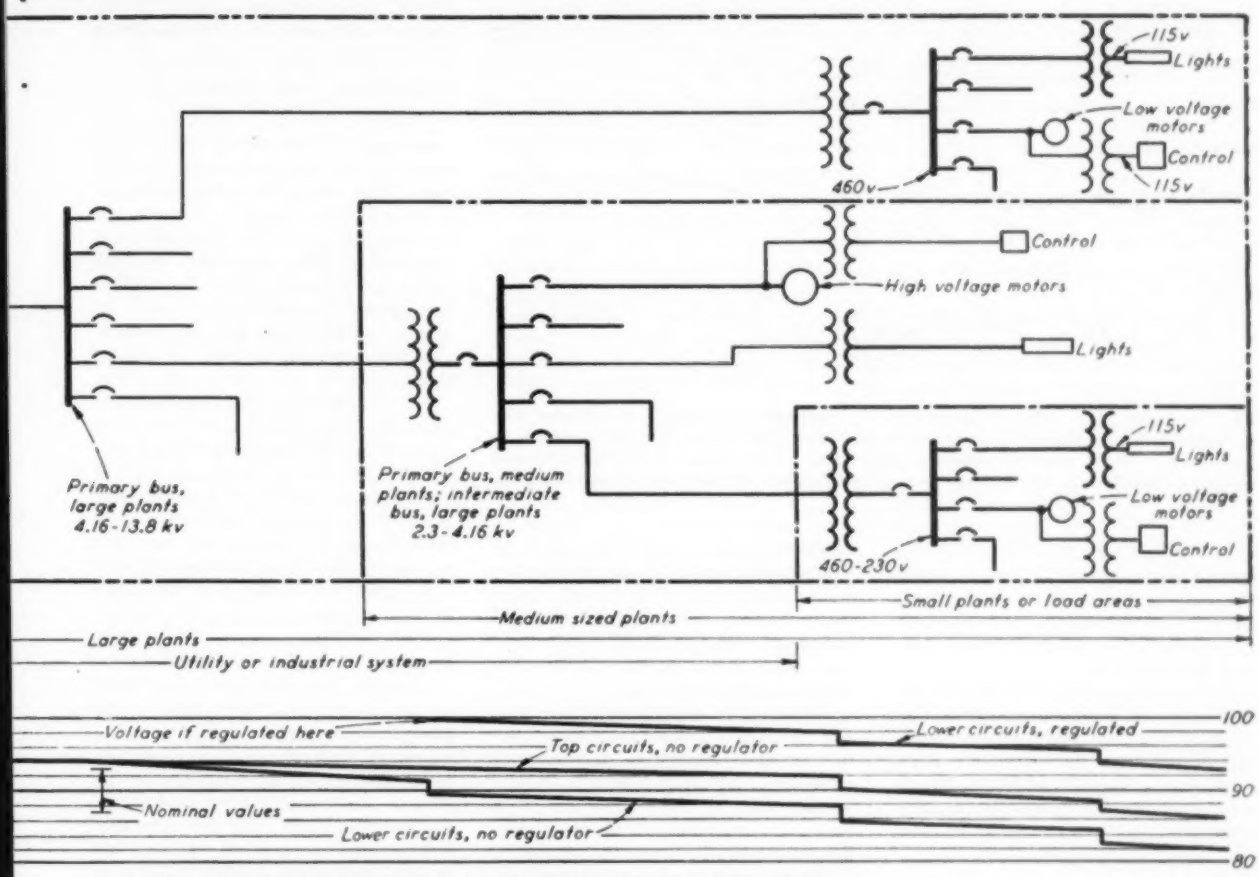
Supply voltage. Utilities as well as industrial plants are subject to these conditions. Consequently, unless there is a regulator very close to the plant primary substation, plant input voltage will vary independently of its load. In general, utilities provide adequate power at reasonably constant voltage. Nevertheless, there is some supply voltage variation which must be considered with the voltage drops in the plant system.

In many cases, supply variations are excessive. There are instances where the utilities simply cannot provide capacity as rapidly as demand increases, a condition likely to be encountered in varying degrees for some time to come. Most difficulty will likely be found on utility circuits supplying several plants in rapidly growing industrial areas, near the end of lines remote from generating or primary loop facilities, and on some small systems in rural areas.

Unusual circuit situations. The second factor would include cases* too diversified to catalog. An example would be isolated circuits such as a line to the pump house that may or may not be improved by other methods such as a higher voltage feeder, with possible exceptions as for regulated control power. Other instances, however, may involve sizable plant areas as where circuit impedance was increased to limit short-circuit currents to reasonable values before an unanticipated load was added.

Unusual loads also form a large group varying from chippers in a pulp mill to resistance welders. Normally, the first step where such loads constitute a large part of plant capacity is to do everything possible to reduce load variations to a minimum and supply a system with enough capacity to further limit voltage variations. All too often, voltage variations are still

**Examples are given in "Dust, Corrosion and Electrical Distribution" in this issue.*



varies from 3 per cent, in some new and coordinated utility and industrial systems, to 20 per cent and more. Momentary overloads, method of power factor correction with synchronous motors or capacitors, utility use of regulators and many other factors affect the no load voltage and voltage changes at the load terminals

excessive for the rest of the plant load, and regulators are worth considering *if the changes occur at a rate and frequency which can be corrected by them.* See discussion on types of regulators.

Laboratory, inspection, control, electronic and other special equipment or loads may require a more constant voltage than necessary for general plant purposes. These loads would ordinarily have to be a very large percentage of the plant capacity to make it desirable (assuming constant plant supply voltage) to reduce system impedance enough to limit variations below normally accepted values. Limits for these loads are often so close that automatic regulators are the only practical solution.

Human factors. Most factors discussed are of a technical nature. They can be analyzed and solutions placed on a sound economic basis. There are, however, many others which, even when recognized, are difficult to assess. Many operations, for example, depend on a number of interrelated factors, one of which may be conversion of electrical energy as a function of the voltage. Normally, in obtaining maximum production, a delicate balance is created with other factors. Thus in some heating and drying operations, in welding and in many other processes, speed or time is closely related to supply voltage and ordinarily regulated to the voltage existing during the bulk of the shift.

Theoretically, when the plant load changes at start or finish of a working period, the operator should be able to readjust speed or time to compensate for the rising voltage. Unfortunately, the same human failings forcing the trend to fully automatic operations account for the fact that more often he does not. This of course means that either quality suffers for a time, increasing rejects and repairs, or the operation must be slowed to a point of less critical conditions, decreasing return on equipment.

Thus it falls to the engineer responsible for the plant services to consider factors similar to the above along with other non-technical problems, such as the optimum time for improving the distribution system. These are balanced with strictly technical factors to determine need for voltage regulators and similar equipment. The aim is to keep the "howling minority" of loads or situations from causing trouble.

CAUSES OF VARIATIONS

First step is a comprehensive, if brief, survey of causes of voltage variation, their extent and their possible effect on various plant loads. Voltage variations are insidious in nature and cannot readily be detected without actual measurement. They often appear from unexpected sources. For example, capacitors added to reduce voltage drop will, unless switched with the load, also cause a rise in no load voltage.

Another common cause of high no load voltage is increase of transformer potential to raise load values. These overvoltages, which may also be found in a survey, can be very harmful.

Knowing the system from the standpoint of voltage variation is highly desirable. Although constant load voltage is the goal, it cannot be

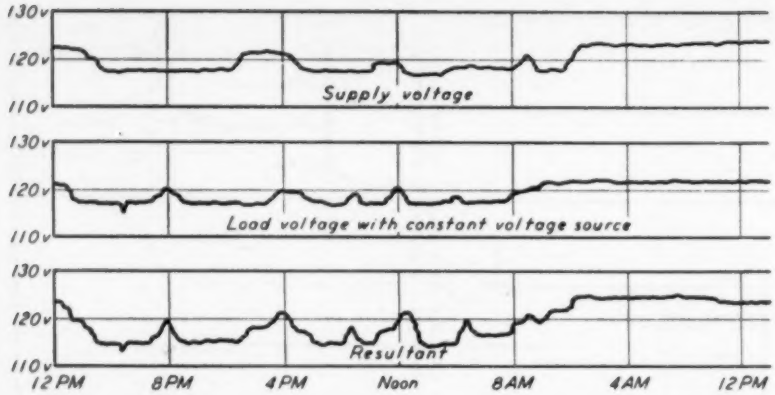


Fig. 2—Total load voltage variations are resultant of supply fluctuations and voltage drops in the area itself, reflecting not only magnitude but composite frequency of both. Load requirements may vary. For example, some processes and equipment need a steady voltage even in preference to limits based on efficiency

fully realized in a practical sense and the problem becomes one of doing the most good for the lowest investment. Consequently, correction at intermediate points, or at the supply, may be preferable.

In general, voltage variations fall into two classes; those caused by changes in voltage input to any circuit and those caused by impedance drops in the circuit itself. The first is always impressed on the second, contributing to the total load voltage spread.

Supply Variations

Commonly the plant engineer is handicapped in any effort to correct voltage fluctuations in the plant supply. Utilities generally are aware of the importance of constant voltage and have already done everything economically feasible to supply it. In such instances, a simple request for better voltage conditions may apparently fall on deaf ears. But backed by a recap of plant conditions in general, a satisfactory discussion on excessive supply voltage variations may be anticipated.

However, better service will result in increased costs which, although temporarily absorbed by the supplier, will ultimately be passed to the consumer. Again, the engineer in the industrial plant must assess the facts and decide the best course for voltage correction before making requests.

Utility supply systems, and voltage changes, vary widely as viewed from the primary substation of a plant. In highly industrialized areas, there will probably be a number of generating plants tied into a distribution network. A larger plant in the midst of the network may be receiving power from several sources in parallel.

Smaller plants may find themselves on a utility intermediate network with or without plants and other loads of similar magnitude whose fluctuations may have their effect. Still other plants in fringe areas will "see" their supply as a long feeder in which their own load is the primary factor contributing to voltage changes.

The supply voltage variations will add to the voltage or impedance drops in the plant system to increase the over-all spread, Figs. 1 and 2. Where supply changes do not coincide with those in the plant, a more rapidly fluctuating load voltage will result.

Usually, the smaller plants will be connected to relatively low voltage utility feeders and subject to greater supply voltage variations. On the other hand, the plant system itself will have, at the most, one transformation and short distribution lines so that the inplant impedance drops may be low. These compensating factors mean that the over-all voltage spread should not be greater than in a larger plant (assuming equal system quality) but that the timing and control of the variations are determined to a greater extent by supply conditions.

Internal Plant Impedances

The actual impedance of each portion of the circuit, Fig. 1, varies almost inversely as its capacity so that the per cent impedance of transformers is nearly the same for all ratings. Thus industrial transformers range from four to six per cent in common sizes. Consequently, voltage regulation, or the change from no load to full load voltage will be substantially equal. Feeder impedance, however, varies with length and conductor spacing.

Thus if the change in load voltage is brought about by the entire plant going from no load to full load, the full regulation of each portion of the circuit, along with variations in the supply circuit, add up to the maximum load voltage spread encountered.

Impedance and Regulation

Voltage drop in a circuit component depends not only on the impedance but on the power factor of the load. For this reason, the rating of a transformer usually includes per cent impedance rather than per cent regulation. Also, impedance of both cables and transformers is used in calculating interrupting capacity required for switchgear and is generally available in specification sheets or tables.

Fig. 3 illustrates that impedance is made up of reactive and resistive components which must be combined vectorially. It should be noted that in general high voltage components have a high reactance to resistance ratio so that impedance is nearly equal to reactance. As voltage decreases, however, resistance becomes a more important factor.

How voltage drop is affected by power factor is also graphically shown in Fig. 3. The impedance drop may be broken down into its resistive and reactive components, the former being in phase with the load current, the latter leading by 90 deg. The vector sum of the two components and the load voltage must equal the impressed primary voltage reduced by the ratio of transformation as shown.

For high power factors, transformer or cable reactance has little effect, and regulation is a fraction of the impedance (both expressed in percentage). However, at lower power factors, impedance drop becomes more nearly in phase with load voltage and subtracts almost directly from the impressed (or corrected primary) voltage. As a result, per cent regulation and impedance become nearly equal. The last diagram illustrates how a leading power factor may cause no load voltage to rise.

From the standpoint of voltage variations, the significance of power factor becomes apparent in considering several commonly met conditions. For example, the value of capacitors and synchronous motors for increasing power factor and reducing system kva and voltage drop must not be discounted. However, they may not decrease voltage variations *unless they are switched with the load* and may even contribute to undesirable overvoltages.

Again, a 100 hp induction motor operating near full load would require possibly only a quarter of the capacity of a 300 kva transformer and substation which at first glance might not seem unreasonable. However, the

power factor at starting drops to 0.5 or less and the kva may well increase to 300. As a result, the per cent voltage variation in the transformer may approach the value of the impedance, or possibly 5 per cent. This may easily be doubled by impedance of the primary feeder and primary substation (or utility) transformer. Consequently, this motor alone may cause variations up to 10 per cent on the load center secondary bus.

The operating cycle of the motor and effect of resulting variations on other equipment served by the substation should be considered. Many types of load would be affected by frequent starting of the motor.

On the other hand, corrective measures might prove difficult. Although somewhat small, it is probable the motor under discussion should have been wound for high voltage and supplied from a separate primary feeder. This would have avoided the major cause of variation—transformer and feeder impedance. In either case, if the degree of voltage fluctuation was objectionable, the short duration of the dips would require almost instantaneous correction.

A regulator which operates too slowly would of course be ineffective. Another operating at medium speed might lag behind the change, and be effective only in decreasing duration of the dip. Furthermore, unless fast enough to follow the voltage rise as the motor accelerates, or unless compensated, it may cause overshoot.

Thus if frequent starting affected other loads, it would appear advisable to supply the motor by a separate line if possible. Otherwise, corrective measures might be limited only to the most critical small loads such as control circuits that could be economically supplied by instantaneous types of regulators.

Resistance welders also usually draw momentary loads well over their nameplate rating. In addition, single phase types have very low power factor and therefore compare with heavy induction motors under starting conditions. Frequently started motors, resistance welders, arc furnaces, reciprocating compressors and the like create rapid fluctuations that are difficult to correct, except for small loads. They should be isolated from loads requiring constant voltage and from lighting circuits as much as possible.

Where a number of heavy motors or welders are employed, the principle of the diversity factor is often used. Individual pieces of equipment are electrically interlocked to limit the number that may draw peak loads at any one time, limiting amplitude of variations but increasing frequency.

It was previously noted that the utility voltage curve is impressed on the plant load voltage curve, producing a composite for the primary bus with more extensive variations than either alone. The composite curve in turn, is the supply curve for each load center, which also will have its own load cycle.

Obviously, the voltage curve at a given load may become a bit complicated, but will probably consist of one or more long cycles with appreciable amplitude upon which is superimposed a series of more rapid fluctuations of lesser magnitude. All of these changes are normally within the range of all automatic regulators. In extreme cases, "instantaneous" types may be necessary for the rapid changes even though larger regulators smooth out the longer cycles.

Where it is possible, human factors may also act to increase voltage variations. For example, in a department where a number of operations are individually controlled by operators, production often proceeds by spurts, with all men taking a rest at the same time. Often the resulting load changes are recognizable on a voltmeter some distance from the department.

EFFECT ON LOADS

In the final analysis, the effect of existing voltage fluctuations on individual types of loads must be considered before corrective measures are taken.

All equipment has maximum and minimum voltage limits specified for reasonable life and operating efficiency, and an optimum value at which best life and efficiency are obtained. These values vary. Although a range of, say 15 per cent is suitable for the majority, other equipment must be held to much closer limits to avoid high replacement costs. In both cases, of course, it is assumed that nominal voltage is such its variations will fall within the high and low limits, or can be adjusted to do so.

In addition to over-all operating efficiency, actual load voltage (at any given time) affects electrical efficiency, capacity, heating, torque, output and similar characteristics in various ways depending on equipment. These might be listed as steady state effects.

In addition, rapidity of fluctuation is often important. Speed of an induction motor, for example, is relatively insensitive. A 20 per cent change in voltage will produce less than a 3 per cent change in speed. Yet if the motor were used in a regulated system having another function, such as flow, dependent on its speed, oscillations with a magnitude several times the normal speed change could conceivably occur. A much more common example of importance of frequency is found in light flicker.

Returning for the moment to the steady state effects, other than incidental mention is probably unnecessary here. For most equipment, change of the various characteristics with supply voltage is covered in detail in handbooks, manufacturers' literature and frequent articles.

More important is a discussion of means of coordinating the information and best methods of correction. For example, a table of such information may show that an induction motor operated at 90 per cent rated voltage has its full load current increased about 11 per cent. This means that to avoid overheating, it must be operated at only 90 per cent capacity. In addition, overload capacity, and starting and maximum running torque are decreased nearly 20 per cent and slip increased 23 per cent.

Consequently, even though equipment were overmotored for better regulation or higher peak demand, capacity is severely limited and a high percentage of equipment investment can produce no return. On the other hand a 10 per cent overvoltage is generally beneficial except where increased starting torque or low power factor may cause trouble.

Now assume a load center area in which a high percentage of the load

TABLE I—FACTORS LEADING TO USE OF REGULATORS

1. Variations (which may or may not be "excessive") in the plant power supply.
2. Unusual plant circuit situations, such as an isolated load area.
3. Unusual loads making up a large part of plant capacity and producing variations objectionable for the rest of the equipment.
4. Conversely, loads or load areas requiring (for electrical reasons) better voltage control or stability than economically feasible for the major part of plant load.
5. Operations where voltage variations and human factors conflict.
6. Loads for which a regulated voltage with an adjustable value is desirable (regulator range must be considered).
7. Situations in which investment-less-salvage value of regulators is low enough to allow delay of consideration or design of a new distribution system until future requirements can be determined.

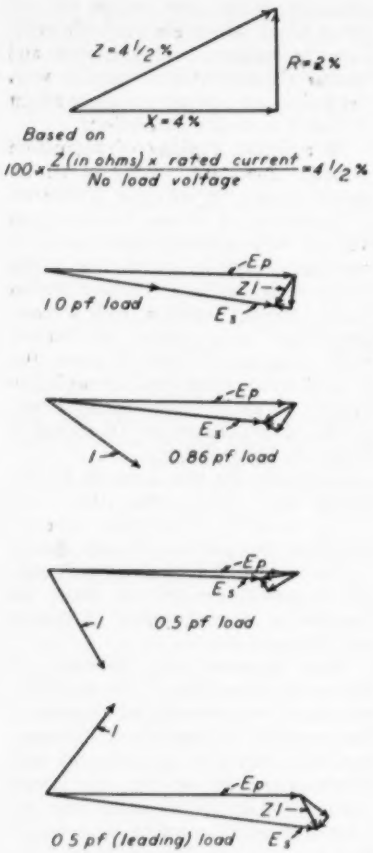


Fig. 3—These sketches illustrate how load power factor is important in the consideration of sources of voltage variation. At top, per cent impedance is broken into reactive and resistive components. The center three diagrams show how lower power factors increase regulation. At bottom, leading current causes voltage rise at load. Voltage drops are exaggerated for clarity.

Examples above apply to transformer reduced to 1:1 ratio, but also illustrate drops in feeders. At the higher voltages, reactance to resistance ratio increases making the effect of power factor on voltage drop more pronounced

is composed of induction motors. Further assume that a combination of conditions produces a total voltage change of 20 per cent. Thus, at the start of the day shift, voltage is 480 v but drops rapidly as load goes on both in the plant and in the surrounding area. During most of the working shift, voltage hovers around 400 v, rising occasionally during slack and lunch periods and again at the end of the shift.

It is important to note here that although the extreme low voltage periods may cover only one half to two thirds of the working day, possibly 80 to 95 per cent of plant output occurs in that time. Therefore, if the final decision is to employ regulators to eliminate the low voltage condition and maintain the nominal 440 v rating for most motors, cost of regulation may be balanced against the 10 to 20 per cent increased capacity of motors and equipment. Other benefits result from decreased heating of motors, bringing longer life and lower maintenance.

Considering only the motors, however, in most cases it would not be unreasonable to raise the transformer voltage, say, 7½ per cent. For although plant voltage at light load would be high enough to have detrimental effects, an extremely small percentage of *production* operations involving motors would take place under that condition.

However, a small but very important portion of plant equipment continues to operate even during low production periods. This would include lights, capacitors, control equipment, inspection and laboratory apparatus, and plant service equipment such as pumps, fans and controls. The bulk of this equipment is far more sensitive to high and low voltage as well as to voltage variations than are induction motors. On the other hand, much smaller regulator capacity is needed. Therefore the problem is to choose the portion of the load most efficiently and advantageously regulated.

Other common types of equipment and the principal ways they are affected by voltage variations are:

Lights

At 90 per cent rated voltage, incandescent lamp output is only 70 per cent rated value although life is increased four times. At 110 per cent voltage, output increases to 140 per cent but life has decreased to one-third normal, and further decreases to one-tenth at 120 per cent. Labor cost in replacing lamps is probably the most important factor here.

Fluorescent lamp output varies almost directly with voltage making them much less sensitive than incandescents. However, excessive undervoltages cause starting difficulties and loss of life, while ballasts may begin to overheat with overvoltages only a few per cent above normal. Mercury lamps, in general, fall midway between the fluorescent and incandescent types.

Long time variations in light output are hard to notice visually so that instrument readings are necessary to insure optimum return on investment. On the other hand, short dips even of small magnitude are easily distinguished and may become very objectionable if repetitive. Thus a 2 per cent voltage dip on an incandescent lamp is objectionable if it occurs once a minute; at five dips per second, the limit is reduced to half of one per cent.

It would be impractical to try to correct rapid fluctuations in a plant lighting load with regulators because of capacity and investment required to obtain adequate speed of response. Slower, high capacity types might even aggravate the condition by causing overshoot, although they would be highly satisfactory for slower variations. Best answer is to isolate lighting from the load causing rapid fluctuations. Fortunately, fluorescent lamps are less sensitive to amplitude of the dips in proportion to their lower voltage sensitivity.

Control Equipment

Except for electronic types, control components are not generally in themselves adversely affected by moderate voltage changes, although extremes* may cause malfunctioning or loss of life. Solenoids, for example, should operate satisfactorily on 10 per cent over-voltage and 15 per cent under voltage. Generally, the same statement applies to complete units having an "On-Off" operation.

However, trouble should be anticipated where any operation, either in the control or in the equipment controlled, is a function of supply voltage. This is particularly true when feedback is involved. Normally, critical potentials such as reference and bias voltages are regulated because variations are greatly amplified by the control equipment. On the other hand, the power controlled is often not regulated and voltage fluctuations pass through the output to a varying degree. Seriousness of the variations depends on the relation of the output quantity to other operations in the process, and to the possibility of being reflected back to the control input where they may be amplified. Regulators with almost instantaneous response up to 5 kva are generally available.

Components in which magnetic saturation is a factor may have characteristics varied by voltage changes.

Electronic Tubes

The importance of constant filament voltage for electronic tubes is often emphasized, for a 5 per cent overvoltage can cut tube life in half. Lightly loaded units and tubes in standby service are generally operated at reduced cathode voltage to prolong life. However, low cathode tempera-

**Examples are mentioned in the article "Important Characteristics of Control Transformers" in this issue.*

ture reduces electron emission, thereby increasing tube drop and anode heating in heavily loaded tubes. Furthermore, in gas filled types, the cathode surface may be partially or completely destroyed by ion bombardment when emission is too low to carry peak anode currents.

Consequently, any attempt to prolong tube life by reducing cathode potential (which is sometimes set high to insure operation) should also insure constant potential to avoid undervoltages. Manufacturers limits are usually given as 5 per cent above and below rated value, but considerably increased life may be obtained with a narrower range. Much electronic equipment is now supplied with regulators, but price prevents extensive use.

Regulating circuits are usually incorporated in electronic equipment for bias and critical plate voltages. However, these are seldom adequate for excessive supply voltage swings. In addition, factors considered under *Control Equipment* generally apply to electronic circuits.

Heating Equipment

Heat developed in a resistance is proportional to the square of the voltage. In thermostatically controlled equipment, this factor would not ordinarily be important, but may become so if rate of heating is significant. Also, overvoltage may affect life of elements operated near top temperature limits or in atmosphere where corrosion or other action such as scale deposit increases rapidly with temperature.

In many operations, heating depends on element temperature and another function such as conveyer speed. Regulation may be important in such cases, which include radiant heating and methods of generating heat by the resistance of the material itself. These processes are seldom thermostatically controlled.

Welding Equipment

Most critical part of resistance welders is the control. This is not too different from other control types, but note that generally it is difficult to isolate it from the load circuit which is a prime cause of variations. Fluctuations in control voltage may cause erratic timing.

As in other heating devices, heat output (with constant time) varies as the square of the power supply voltage, and welding conditions are often so critical, particularly on military work, that good voltage conditions are essential. Adequate capacity in the distribution system is necessary. In addition, plant or feeder voltage regulation is often desirable to avoid power supply variations, with possible exceptions where compensation is included in the welder control.

In a-c and rectifier types of arc welders, output varies almost directly as the supply voltage. M-g sets are not so sensitive. But for maximum production, operating speeds are normally pushed to the critical point so that voltage variations can be quite detrimental.

A factor often overlooked, although common to many types of equipment, is particularly noticeable in all welders. Internal resistance also affects output, particularly in d-c equipment (including low frequency resistance types). Since high supply voltage often coincides with idle periods for the welder, exceptionally high current for the first few operations thereafter results from the combined effect of high voltage and low winding resistance. Constant voltage could usually hold output within acceptable limits and at the same time permit higher average production.

Capacitors

The kva drawn by capacitors varies as the square of the voltage. At 90 per cent of rated value they are only 81 per cent effective. On the other hand, internal heating increases rapidly toward limiting values for the insulation as kva and potential increase with excessive overvoltages. When connected on utilization circuits to reduce the system load, they are subject to the maximum variation. Consequently, some savings in capacitor cost may be applicable towards voltage control if both are desirable.

Inspection, Laboratories

Much of the electrical equipment, particularly the precision types, purchased for these applications has voltage regulators included. However, special equipment must often be provided for individual problems, with as great, or even greater, need for constant voltage. Spot or area regulation may be desirable depending on how operations are grouped.

VOLTAGE REGULATORS

Space in this article prohibits a truly comprehensive survey of voltage regulators, but brief consideration of the principal types and their characteristics and applications is necessary in considering the point of application and the extent to which they should be used.

The discussion thus far has been based on the type of equipment designed to automatically hold system or load voltage within narrow predetermined limits. However, in considering the problem as a whole, some of the related types will necessarily enter the engineer's picture and will be included here for comparison and background.

Mode of Operation

Most regulators, such as the autotransformer or tap changing types and the induction regulator types, may be operated either manually or auto-

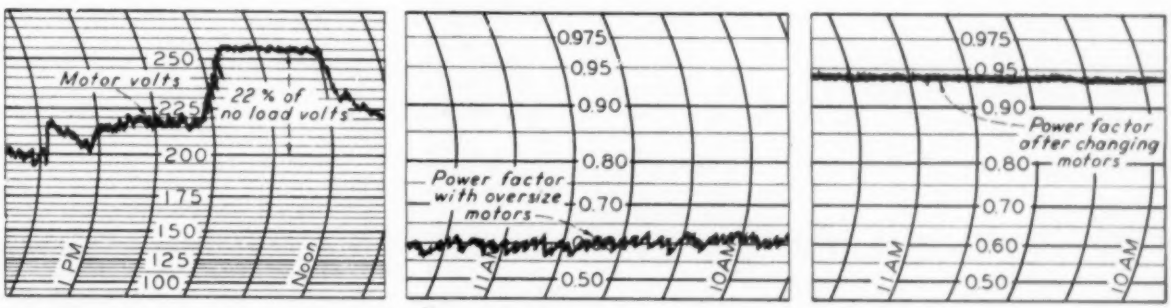


Fig. 4—A survey of the plant system and loads may disclose electrical inefficiency and malfunctioning from voltage variations, as well as the cause. But limit regulators to applications where analysis shows them to be most economical methods of correction. Along with Fig. 3, case history, above, supplied by the Esterline-Angus Company, shows how lightly loaded motors caused trouble. Changes to synchronous motors in some cases and to reduced sizes in others corrected condition for the majority of loads. However some loads need closer regulation than normally obtained

matically. While manual operation may be practical and an important phase in many operations, it is to be expected that it would be reserved for situations where an operator is on duty at all times and where voltage swings are predictable. In general, "instantaneous" completely electrical types cannot be manually operated with the possible exception of provisions for changing output voltage.

In the types which are available for either manual or automatic operation, the latter method is usually provided by adapting manual designs to be controlled by a positioning motor. The motor in turn may be controlled by a voltage sensitive unit which may or may not include line drop compensation in its circuit.

Completely electrical types have no moving parts except for auxiliary adjustments. The impedance characteristic of one or more of the electrical components, which may be in either shunt or series relation to the load current, varies in response to voltage changes and controls the output voltage. Examples are a shunt capacitor paralleled with a saturating inductance controlling a series transformer and a circuit incorporating a vacuum tube whose plate resistance is changed in response to grid signal variations. Most electrical types are more or less inefficient because of power consumed in ballast or regulating circuits. This normally limits sizes to 1 kva or less although some are available up to 5 kva or more.

Types

Because of the variety of designs, the description immediately preceding will have to suffice for electrically operated types except to note that transformation from high to low voltages, or the reverse, may or may not be incorporated in the regulator.

Tap changing types have a mechanism for switching taps either on a power transformer winding or (particularly where point of regulation is removed from power transformers) on an auxiliary autotransformer. Taps are often spaced for ⅝ per cent voltage change. Range of regulation is usually limited to 5 to 10 per cent above and below normal voltage to reduce size of the voltage control equipment. In some cases a further reduction is obtained by using a single coil for both buck and boost, and reversing connections as necessary.

Step regulators are generally tapped transformers for changing voltage in small steps, usually under load, along with the necessary tap changer or load ratio control mechanism. The latter is equipment for changing transformer ratio under load and, while normally used on power transformers, may also be applied to autotransformers. Either a preventive autotransformer in the large sizes or resistance in series with the contacts in the smaller sizes will be used to limit circulating currents during switching since the load current cannot be interrupted. For automatic operation, step regulators are usually motor driven. However, in some types involving a small number of steps (resulting in relatively large voltage steps) contactors may be used.

Variable transformers are usually autotransformers designed so that a brush may make contact directly on an exposed portion of the winding, providing, in effect, a tap for every turn (or alternate turn) but avoiding the plurality of tap leads otherwise required. There are also two winding transformers, particularly in small sizes, in which the secondary is isolated from the input. Multiphase units, provided by coupling the required number of single phase transformers together, are available.

Variable transformers are normally designed to vary output voltage over the entire range from zero to 110 or 115 per cent (sometimes 200 per cent or more) of input voltage and are therefore advantageous where a wide range of load voltage is needed. Brush rotation requires no torque other than that necessary to overcome friction and manual operation is usually adapted to automatic control by employing a positioning motor. Three phase types up to 100 kva are available.

Induction regulators are two winding transformers designed like a motor so that mutual inductance between primary and secondary may be varied by rotating the latter. The voltage change is continuous (i.e. without steps) and connections are permanent, avoiding brush wear. However, considerable torque is developed by the rotor, requiring either larger or slower positioning equipment than other regulators. A small "dead band" is usually provided to avoid continuous control operation. Construction is generally more expensive but may be balanced against lower maintenance costs.

Induction types also may be designed to cover the entire range of voltage from zero to maximum or above and are valuable where a wide range of controlled voltage is needed. However, for the more common application of holding load voltage constant, they are normally designed for a 7½ to 10 per cent buck or boost. This, of course, reduces the kva and size required, which is almost proportional to the change in output voltage available.

Industrial types range up to several hundred kva in size and are sometimes incorporated in a package unit, with step down transformer and breaker, for lighting loads and the like.

Capacitors should also be considered when the intention is only to reduce voltage variations. They may be connected to the substation bus through switching equipment so that the number of units on the line varies with load or voltage, thus controlling the system impedance drops. Obviously, constancy of the voltage as well as range that can be covered is limited. Another method, connecting capacitors directly to load so that they are switched off with the load, can also only reduce voltage drop and avoid high no load voltages. Individual motors should not be overcorrected.

Synchronous motors can be used in the same manner as capacitors to *reduce* voltage variations by controlling power factor through field excitation.

Generator voltage controls, in plants which produce part of their own power, may also be used to regulate load voltage to an extent depending on the situation. However, they can seldom provide constant voltage for a given load or plant area.

Speed of Response

In the "instantaneous" types having an all electrical mode of operation, correction within three cycles (60 c current) is usually specified, although in some of the small vacuum tube units the response may approach truly instantaneous correction. The three cycle time is usually adequate for variations of reasonable amplitude except where such changes are introduced into equipment which may amplify them.

Response of motor driven types may vary widely but is relatively slow. For example, 20 sec may be required for a voltage change covering the complete range of 10 per cent below to 10 per cent above normal. However, only 5 sec would be required for a 5 per cent change, which would include the majority of sudden variations encountered, and so on. Speed is adequate for all but rapid fluctuations, such as caused by motor starting, previously mentioned.

While the motor driven types are most suitable and least expensive in maintaining the most efficient constant voltage for a heavy load or a large plant area, they cannot cope with very rapid changes nor with variations in individual circuits where several are controlled by one regulator. Thus an instantaneous type may be necessary on, for example, electronic controls even though the power supply for the area is regulated by a larger type.

M & O INVESTIGATES FLY ASH COLLECTOR EFFICIENCY

After installing fly ash collectors, the Minnesota and Ontario Paper Co. went about testing the units to find out their efficiency. Here is the test procedure they employed, and the results they obtained

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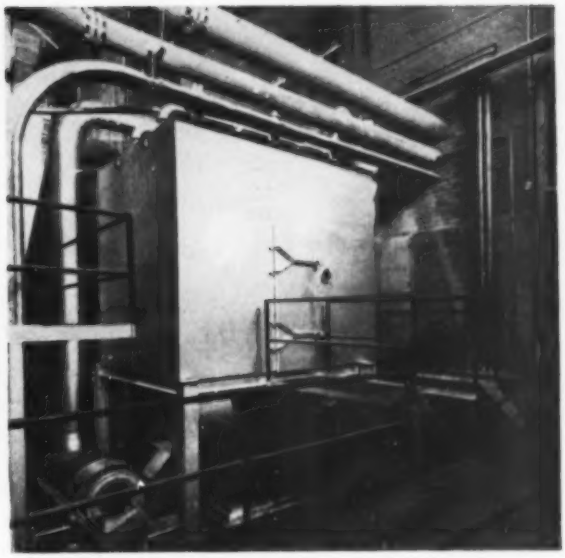


This collector recovers fly ash from bark burning boiler

MANY of the older plant installations of the Minnesota and Ontario Paper Company were such that no provision was made in equipment design for space for suitable fly ash separators. The steam generating plant of M and O at International Falls has seven steam generators, five were installed during 1927-1929, the other two units being installed in 1939 and 1946 respectively. Each of the first five units was designed to generate 80,000 lb steam per hr at 450 psi, 580 TT, using pulverized bituminous coal. Crowded into restricted space, application of suitable fly ash separators is a complex problem. Furthermore, since these units must be considered for replacement, large expenditures for fly ash separators at this time may be better applied in the design of any contemplated modern unit.

Steam generators installed in 1939, designed for 80,000 lb steam per hr at 450 psi, 600 TT offer better space and application as also does the unit installed in 1946, designed for 150,000 lb steam per hr at 450 psi, 600 TT. These last two units will be equipped with fly ash separators in the near future.

In making installation of any fly ash separator equipment, however, any steam generation reduction in already overtaxed steam production units must be avoided and may require modification of fan capacities.

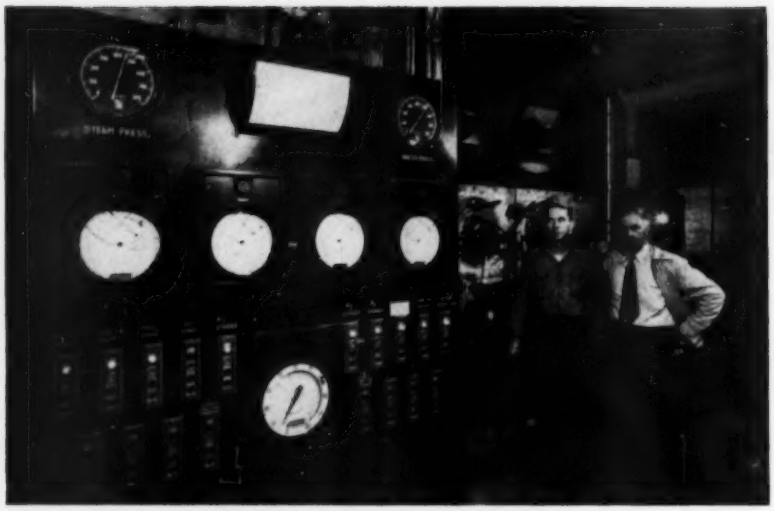
Heavy fly ash emission from the Kraft recovery unit was very successfully eliminated with the installation of an electrostatic precipitator. This situation was a source of critical waste and nuisance, and its correction provided economy, better products, and a cleaner, more healthful, surrounding.

One of the major nuisance problems has been definitely improved with the installation of fly ash collector in conjunction with the bark burning boiler. Since the air intakes to paper machines and other manufacturing divisions were exposed to this fly ash hazard, contamination was soon evident. This contamination resulted in reaching a decision to obtain samples and necessary data for possible application of an effective fly ash catcher.

Owing to the characteristics of the fly ash particle such as size, density, and volume, considerable difficulty was anticipated in obtaining a highly effective unit for application on this bark burning unit. The furnace combustion design was restricted, thus necessitating high gas velocities in order to obtain burning capacity for quantities of bark involved.

This condition resulted in a carryover of combustible and fly ash being discharged to atmosphere. The bark burning unit was originally estimated to produce 50,000 lb steam per hr at 450 psi, 600 TT and utilizes as fuel, waste bark, wood waste, and sawdust.

Here is a general view of the barking process and flat screen. Conveyer in foreground transports bark to hog



Operator can perform all functions necessary to obtain maximum efficiency from the bark burning boiler from this centrally located control panel board

Bark and wood waste is processed through screens, hoggers, and dewatering presses and finally passed into the furnace with varying moisture ratios of from 50 to 55 per cent.

The fly ash separator selected utilizes aerodynamic force through a cone shaped unit. The surface of each cone has a louvered surface, which effectively and with low frictional loss separates the particles. The unit was designed for a capacity of 65,000 cfm and a pressure drop at operation temperature of 1 in. wg.

High separating efficiency of the unit was soon very apparent and the following tests were made in order to obtain operating data. Preparations for the test and a preliminary survey of gas velocities, dust loadings, and temperature variations were made.

When testing for collector efficiency any one of three methods may be used:

(1) Determination of the dust loading of the gas at both the collector inlet and outlet.

$$\text{Collector efficiency} = \frac{\text{Inlet grain loading—Outlet grain loading}}{\text{Inlet grain loading}}$$

(2) Determination of the dust loading at the collector inlet and weight of dust caught in the collector during the test.

$$\text{Collector efficiency} = \frac{\text{Catch grain loading}}{\text{Inlet grain loading}}$$

(3) Weight of dust caught in collector during the test and determination of dust loading at collector outlet.

$$\text{Collector efficiency} = \frac{\text{Catch grain loading}}{\text{Catch grain loading and outlet loading}}$$

To insure a uniform gas flow, a point of test in a straight section of flue away from bends or other points of disturbance to gas flow was chosen. Due to the high turbulance caused by the induced draft fan and wide variation of dust loading through the cross section of the short ducts ahead of the collector, determining dust loading at the collector inlet was con-

Test No. 1

A. Sampler nozzle on stack

1-Time of collection, t = 18 min
2-Temperature of sampler, T_s = 220 F = 680 Abs
3-Temperature of gas, T_g = 400 F = 860 Abs
4-Static pressure sampler = 0.7 in. wg
5-Collected in jar = 0.298 grams
6-Collected in bag = 0.010 grams
7-Total collected, W = 0.308 grams
8-Equivalent volume at 70 F, 530 Abs (4), V_1 = 7.0 cfm
9-Volume corrected to temperature (2, 8) V_2 = 9.0 cfm
10-Actual cfm at temperature in the duct, V

$$\frac{V}{V_2} = \frac{T_g}{T_s}\sqrt{\frac{T_s}{530}}$$

$$V = 9 \times \frac{860}{680} \times 1.13 \times 12.85 \text{ cfm}$$

11-Grain loading $= \frac{W \times 1543}{t \times V} = \frac{0.308 \times 15.43}{18 \times 12.85} = 0.0205 \text{ gr/cu ft}$

B. Dust trapped in collector

1-Time of collection, t = 20 min
2-Weight of dust collected, W = 28.125 lb
3-Temperature of gas, T_g = 400 F, 860 Abs
4-Volume of gas based on ID fan capacity = 63,000 cfm at 550 F
5-Volume corrected to gas temperature (3)

$$63{,}000 \frac{860}{1010} = 53{,}600 \text{ cfm at } 400\text{F}$$

6-Catch grain loading

$$\frac{28.125 \times 7000}{20 \times 53{,}600} = 0.1836 \text{ gr/cu ft}$$

C. Collector efficiency

$$\text{Eff} = \frac{0.1836 \times 100}{0.1836 + 0.0205} = 90 \text{ per cent}$$

Test No. 2

A. Sampler nozzle on stack

1-Time of collection, t = 18.5 min
2-Temperature of sampler, T_s = 245 F, 705 Abs
3-Temperature of gas, T_g = 400 F, 860 Abs
4-Static pressure sampler = 0.70 in wg
5-Collected in jar = 0.243 grams
6-Collected in bag = 0.010 grams
7-Total collected, W = 0.253 grams
8-Equivalent volume at 70 F, 530 Abs (4), V_1 = 7.0 cfm
9-Volume corrected to temperature (2, 8) V_2 = 9.31 cfm
10-Actual cfm at temperature in the duct, V

$$\frac{V}{V_2} = \frac{T_g}{T_s}\sqrt{\frac{T_s}{530}}$$

$$V = 9.31 \times \frac{860}{705} \times 1.15 = 13.1 \text{ cfm}$$

11-Grain loading $= \frac{W \times 1543}{t \times V} = \frac{0.253 \times 15.43}{18.5 \times 13.1} = 0.0161 \text{ gr/cu ft}$

B. Dust trapped in collector

1-Time of collection, t = 20 min
2-Weight of dust collected, W = 46.313 lb
3-Temperature of gas, T_g = 400 F, 860 Abs
4-Volume of gas based on ID fan capacity = 63,000 cfm at 550 F
5-Volume corrected to gas temperature (3)

$$63{,}000 \frac{860}{1010} = 53{,}600 \text{ cfm at } 400\text{F}$$

6-Catch grain loading

$$\frac{46.313 \times 7000}{20 \times 53{,}600} = 0.302 \text{ gr/cu ft}$$

C. Collector efficiency

$$\text{Eff} = \frac{0.302 \times 100}{0.302 + 0.016} = 95 \text{ per cent}$$

sidered impractical. Method 3 was decided upon as the most accurate means of testing because of the smallest possibility of error in obtaining representative samples. Provision was made to retain and weigh the dust trapped by the collector during the period of the test and simultaneously sample the dust loading of the gas leaving the collector. The gas was sampled at a point in the stack just above the roof line where the velocity was fairly uniform.

Gas sampling equipment used was a standard sampler, which contained the following parts: (1) sampling nozzle, (2) glass jar receptacle for precipitating major part of the dust, (3) filter bag on tube outlet to catch dust not precipitated in jar, (4) suction fan with butterfly valve at inlet to control velocity of gas through sampling nozzle, (5) inclined draft gage to indicate velocity through sampler, and (6) thermometer for temperature at sampler.

This equipment extracts a certain volume of gas from the main gas stream. The dust content is precipitated into a receptacle or filtered out by the bag. The receptacle and bag were weighed dry before and after the test so as to determine the exact amount of dust in the gas. The weight of the dust trapped during the run of the test, when reduced to grams avoirdupois and divided by the total volume in cubic feet, represents the loading of the gas.

"Fixed Point" traverse method was employed in sampling the gas through the cross sectional area of the stack. The nozzle was fixed in a stationary position at each sampling point for equal intervals of time during each test. The test apparatus was set and maintained at the predetermined mean velocity of the stack in order that the gas would be drawn through the sampling nozzle at approximately the same velocity as that of the gas passing the nozzle in the stack.

Tests 1, 2, 3, and 4 show the results obtained from four different test runs.

Results indicate that the collector has a dust separation efficiency of approximately 92 per cent. These results are contingent on the following factors, which contribute to possible sources of error and limitation in accuracy:

(1) Due to variable rate of combustion in the furnace there was some variation in stack temperature and velocity with resultant change in condition for sampling.

(2) The heavier dust particles gradually bank off to the sides of the stack and fall by gravity to the bottom. Although some fly ash is precipitated in the base of the stack, the relative quantity is not appreciable (approximately 9 cu ft during a two week period).

During the last three tests, a 55 gal drum was filled with the fly ash caught by the collector in a period of 55 min. This represents a quantity of 106.56 lb or about 7.3 cu ft that was formerly discharged to the mill yard and surrounding area. This fly ash separator has now been in operation for over six months and to date very satisfactory results have been experienced. The effect on the surrounding area is very apparent. The unit has had no maintenance problems.

Of course, properly designed combustion equipment will greatly reduce any smoke or fly ash hazard and minimize the load on fly ash collectors. Careful study and the application of experienced engineering design on any intended installation of new modern steam generators must be made. The types of fuel the proposed units are required to burn must be anticipated. An intelligent application thus results in the minimum expenditures for costly smoke and fly ash eliminators and further reduces operating "headaches".

Test No. 3

A. Sampler nozzle on stack

1 - Time of collection, t — 19.5 min
2 - Temperature of sampler, T_s — 240 F, 700 Abs
3 - Temperature of gas, T_g — 400 F, 860 Abs
4 - Static pressure sampler — 0.70 in. wg
5 - Collected in jar — 0.275 grains
6 - Collected in bag — 0.010 grains
7 - Total collected, W — 0.285 grains
8 - Equivalent volume at 70 F, 530 Abs (4), V_1 — 7.0 cfm
9 - Volume corrected to temperature (2, 8) V_2 — 9.25 cfm
10 - Actual cfm at temperature in the duct, V

$$\frac{V}{V_2} = \frac{T_g}{T_s}\sqrt{\frac{T_s}{530}}$$

$$V = 9.25 \times \frac{860}{700} \times 1.15 = 13.05 \text{ cfm}$$

11 - Grain loading $= \frac{W \times 1543}{t \times V} = \frac{0.285 \times 1543}{19.5 \times 13.05} = 0.0173$ gr/cu ft

B. Dust trapped in collector

1 - Time of collection, t — 20 min
2 - Weight of dust collected, W — 30.313 lb
3 - Temperature of gas, T_g — 400 F, 860 Abs
4 - Volume of gas based on ID fan capacity - 63,000 cfm, 550 F
5 - Volume corrected to gas temperature (3)

$$63{,}000 \times \frac{860}{1010} = 53{,}600 \text{ cfm at } 400\text{ F}$$

6 - Catch grain loading

$$\frac{30.313 \times 7000}{20 \times 53{,}600} = 0.198 \text{ gr/cu ft}$$

C. Collector efficiency

$$\text{Eff} = \frac{0.198 \times 100}{0.198 + 0.017} = 92 \text{ per cent}$$

Test No. 4

A. Sampler nozzle on stack

1 - Time of collection, t — 14.5 min
2 - Temperature of sampler, T_s — 238 F, 698 Abs
3 - Temperature of gas, T_g — 400 F, 860 Abs
4 - Static pressure sampler — 0.70 in. wg
5 - Collected in jar — 0.248 grains
6 - Collected in bag — 0.010 grains
7 - Total collected, W — 0.258 grains
8 - Equivalent volume at 70 F, 530 Abs (4), V_1 — 7.0 cfm
9 - Volume corrected to temperature (2, 8) V_2 — 9.23 cfm
10 - Actual cfm at temperature in the duct, V

$$\frac{V}{V_2} = \frac{T_g}{T_s}\sqrt{\frac{T_s}{530}}$$

$$V = 9.23 \times \frac{860}{698} \times 1.13 = 13.05 \text{ cfm}$$

11 - Grain loading $= \frac{W \times 1543}{t \times V} = \frac{0.258 \times 1543}{14.5 \times 13.05} = 0.21$ gr/cu ft

B. Dust trapped in collector

1 - Time of collection, t — 15 min
2 - Weight of dust collected, W — 29.94 lb
3 - Temperature of gas, T_g — 400 F, 860 Abs
4 - Volume of gas based on ID fan capacity - 63,000 cfm, 550 F
5 - Volume corrected to gas temperature (3)

$$63{,}000 \times \frac{860}{1010} = 53{,}600 \text{ cfm at } 400\text{ F}$$

6 - Catch grain loading

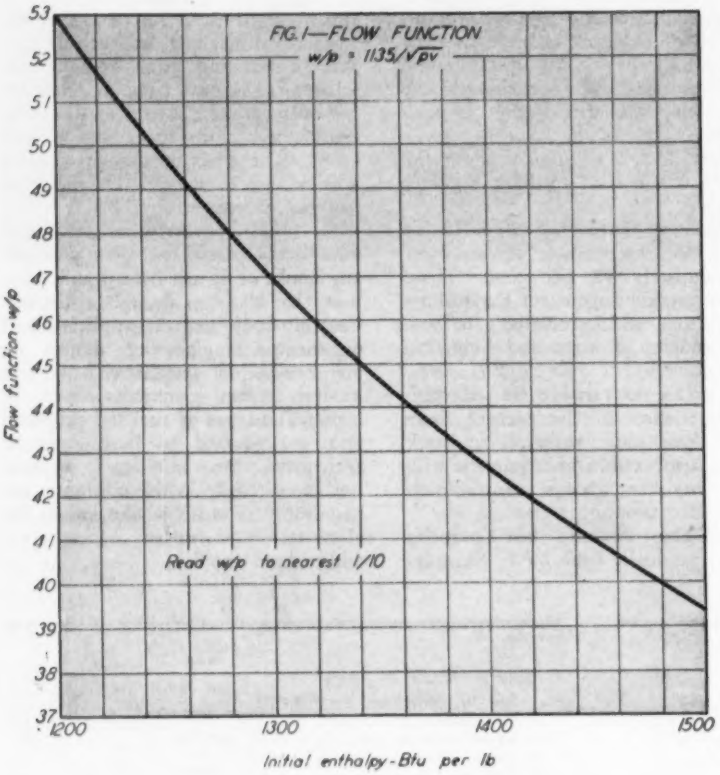
$$\frac{29.94 \times 7000}{15 \times 53{,}600} = 0.2606 \text{ gr/cu ft}$$

C. Collector efficiency

$$\text{Eff} = \frac{0.261 \times 100}{0.261 + 0.021} = 93 \text{ per cent}$$

HEAT RATE CORRECTION FACTORS

for Steam Turbines with varying Initial Pressure, Initial Temperature, or Back Pressure



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GUARANTEE steam conditions of steam turbines seldom agree with the actual operating conditions. Therefore, determining heat rates at the actual steam conditions is often an important consideration. This article provides means for finding heat rate correction factors for initial pressure, initial temperature, and back pressure. In addition, a composite performance curve for a turbine and condenser is developed in a readily understood manner with an example that can be transposed easily to any other turbine and condenser. Tables of correction factors for initial pressure, initial temperature, and back pressure to be applied to the base nonextraction steam rates also are included.

The following data assume steam rate, heat rate, and final feedwater temperature at each fraction of load are available at the guarantee steam conditions. If some of these data are missing, it may be worked up by meth-

PART 1 — DERIVATION OF HEAT RATE CORRECTION FACTORS FOR INITIAL PRESSURE OR INITIAL TEMPERATURE

Note: Example is for a 10,000 kw, 60 cycle turbine-generator designed for 600 psig, 825 F TT steam and 1.5 in. Hg absolute back pressure

Line	Symbol	Source	Description	Pressure		Temperature	
1		Given	Load	4/4	4/4	4/4	4/4
2		Given	Base initial pressure and temperature	600	600	825	825
3	H_o	At 2	Base initial enthalpy, Btu per lb	1420.9	1420.9	1420.9	1420.9
4		Fig. 1 at 3	Base initial w/p	41.9	41.9	41.9	41.9
5	SR_1	Given	Base nonextraction steam rate, lb per kwhr	8.48	8.48	8.48	8.48
6		Fig. 5	Base "Equivalent Final Pressure" of feedwater, psia	125	125	125	125
7	h_f	At 6	Base final enthalpy of feedwater, Btu per lb	315.7	315.7	315.7	315.7
8		3 — 7	Base heat added in boiler, Btu per lb	1105.2	1105.2	1105.2	1105.2
9		Given	Heat rate at base condition, Btu per kwhr	10,450	10,450	10,450	10,450
10		Select	New initial pressure, psig; or temperature, deg F	650	550	850	800
11	H_o	At 10	New initial enthalpy, Btu per lb	1419.9	1423.0	1434.6	1407.0
12		Fig. 1 at 11	New initial w/p	41.9	41.8	41.4	42.4
13		At 10	Steam rate correction factor	0.998	1.002	0.980	1.020
14		5 × 13	New nonextraction steam rate, lb per kwhr	8.46	8.50	8.31	8.65
15		4/12	Inverse ratio of w/p	1.00	1.002	1.012	0.988
16		6 × 13 × 15	New "Equivalent Final Pressure" of feedwater, psia	124.7	125.5	124.0	126.0
17	h_f	At 16	Final enthalpy of feedwater, Btu per lb	315.5	316.1	315.4	316.4
18		11 — 17	Heat added in boiler, Btu per lb	1104.4	1106.9	1119.2	1090.6
19		18/8	Direct ratio of heat added in boiler	0.999	1.002	1.013	0.987
20		13 × 19	Heat rate correction factor	0.997	1.004	0.993	1.007
21		9 × 20	Heat rate at new condition, Btu per kwhr	10,420	10,490	10,380	10,520
22	F_T	21 × load/18	Throttle flow with feedwater heating, lb per hr	94,300	94,700	92,800	96,400
23	h_c	At back pressure	Enthalpy of liquid, Btu per lb	59.7	59.7	59.7	59.7
24		17 — 23	Actual heat rise of feedwater, Btu per lb	255.8	256.4	255.7	256.7
25		Fig. 4 at 24	Total extraction as per cent of throttle flow	23.3	23.3	23.3	23.3
26		22 × 25/100	Total extraction flow, lb per hr	22,000	22,100	21,600	22,500
27	F_c	22 — 26	Flow to condenser, lb per hr	72,300	72,600	71,200	73,900

ods given in the article, *"Calculation of Comparable Heat Rates of Steam Turbines"*, INDUSTRY AND POWER, Dec. 1952, which includes an explanation of the empirical term "Equivalent Final Pressure" of feedwater used in the calculations.

Additional correction to the "Equivalent Final Pressure" of the feedwater must be applied for Parts 1 and 3. As this item is related to steam pressure in the heater, which is proportional to turbine shell pressure, any change in steam condition in the turbine will affect this pressure.

In these methods, there is a change in initial enthalpy, and hence a change of enthalpy at the extraction point, when initial steam conditions vary. Since a means of correcting the pressure of a turbine stage when only initial enthalpy values are known is required, it is necessary to develop a pressure vs enthalpy expression.

It is well known that the flow of superheated steam through a turbine nozzle is proportional to $p/\sqrt{pv}$; where p is the initial steam pressure in psia, and v is the initial specific volume in cu ft per lb. A close approximation for nonrestricted flow of superheated steam through a nozzle is given by the equation $w=1135\ p/\sqrt{pv}$; where w is the flow in lb per hr per sq in. of nozzle area. An inspection of the steam tables will indicate that the $\sqrt{pv}$ varies over a relatively small range for a large range of steam conditions; hence, if w is divided by p, the resultant will vary over a small range.

Fig. 1 is a plot of $w/p=1135/\sqrt{pv}$ vs initial enthalpy using data from *"Thermodynamic Properties of Steam"*, 1936 Edition, by Keenan and Keyes. From this curve, it is obvious that, at constant flow, initial pressure on the nozzle varies inversely as w/p.

Table 1 develops a comparison between the ratio of w/p values at two initial conditions and the ratio of w/p values at a point in a turbine assuming constant turbine efficiency of 80 per cent for the expansion. From this tabulation, it is apparent that for a given change of initial temperature the ratio of the flow function w/p at initial enthalpy values is essentially the same as the ratio at final enthalpy values. Therefore, it is not necessary to know

PART 2 — DERIVATION OF HEAT RATE CORRECTION FACTORS FOR BACK PRESSURE

Line	Symbol	Source	Description
1		Given	Load
2	H_o	Given	Initial enthalpy, Btu per lb
3		Given	Base back pressure, in. Hg absolute
4	SR_1	Given	Base nonextraction steam rate, lb per kwhr
5	p	Fig. 5	Base "Equivalent Final Pressure" of feedwater, psia
6	h_{f1}	At 5	Base final enthalpy of feedwater, Btu per lb
7		2 — 6	Base heat added in boiler, Btu per lb
8	HR_1	Given	Heat rate at base back pressure, Btu per kwhr
9		Select	New back pressure, in. Hg absolute
10		At 9	Back pressure correction factor
11	SR_2	4 × 10	Nonextraction steam rate at new back pressure, lb per kwhr
12		5 × 10	"Equivalent Final Pressure" at new back pressure, psia
13	h_{f2}	At 12	Final enthalpy of feedwater at new back pressure, Btu per lb
14		6 — 13	Extra heat added in boiler at new back pressure, Btu per lb
15		1 + (14/7)	Ratio of heat added in boiler
16	HR_2	8 × 10 × 15	Heat rate at new back pressure, Btu per kwhr
17		10 × 15	Heat rate correction factor
18		7 + 14	Heat added in the boiler, Btu per lb
19	F_T	16 × Load/18	Throttle flow with feedwater heating, lb per hr
20	h_c	At 9	Enthalpy of liquid at back pressure, Btu per lb
21		13 — 20	Actual heat rise of feedwater, Btu per lb
22		Fig. 4 at 21	Total extraction as per cent of throttle flow
23		19 × 22/100	Total extraction flow, lb per hr
24	F_c	19 — 23	Flow to condenser, lb per hr

FIG. 2—TURBINE AND CONDENSER PERFORMANCE
10,000 kw-60 cycle-600 psig-825 F
4 stages of feedwater heating

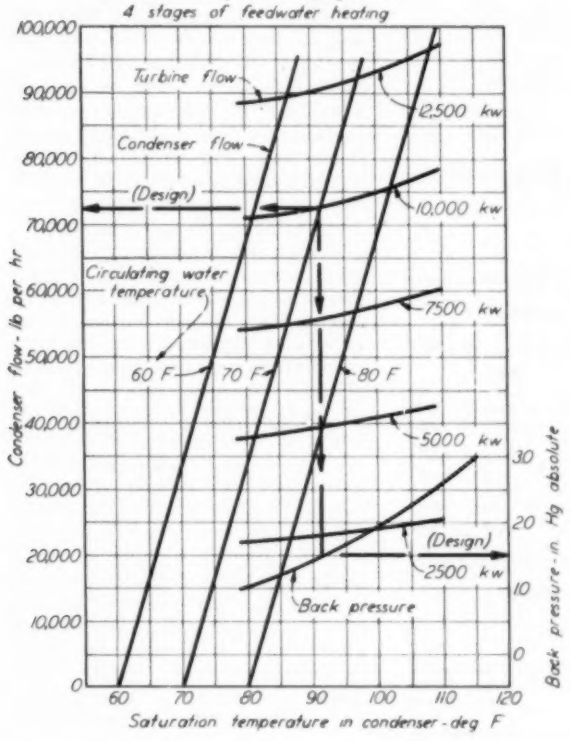
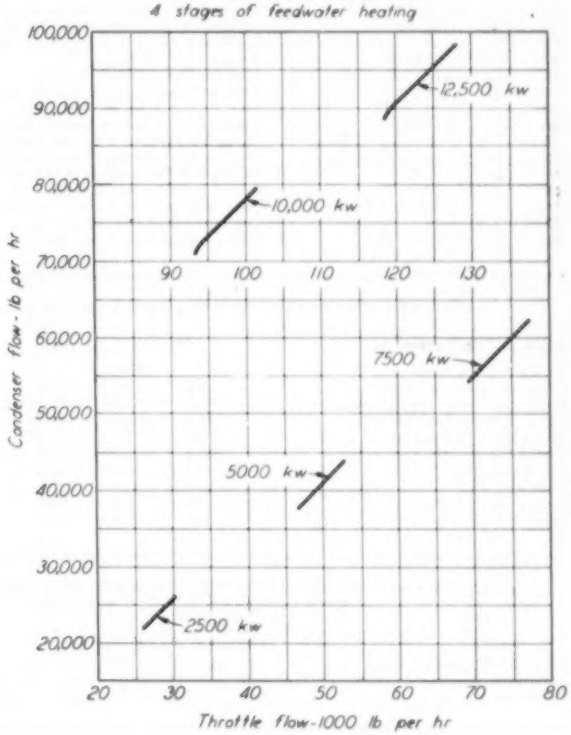
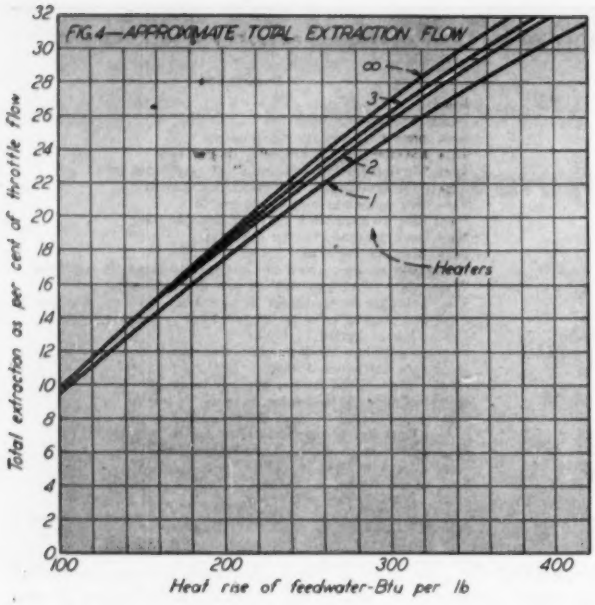


FIG. 3—CONDENSER FLOW VS THROTTLE FLOW
10,000 kw-60 cycle-600 psig-825 F
4 stages of feedwater heating





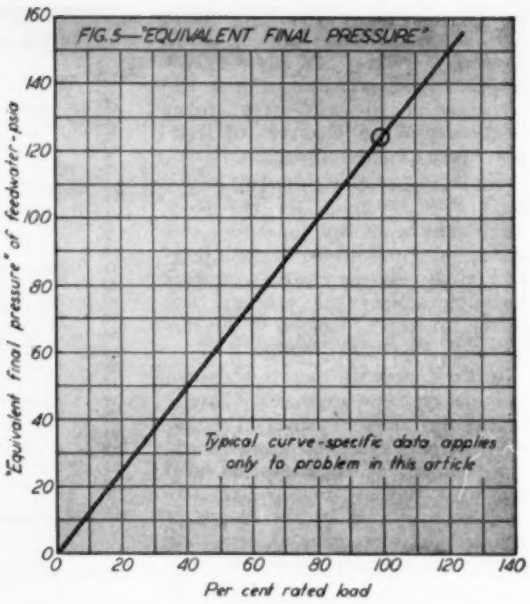


FIG. 5—"EQUIVALENT FINAL PRESSURE"
"Equivalent final pressure" of feedwater-psia
Per cent rated load
Typical curve-specific data applies only to problem in this article

PART 3 — HEAT RATE CORRECTED FOR PRESSURE, TEMPERATURE AND BACK PRESSURE

Line	Symbol	Source	Description
1		Given	Load
2		Given	Base initial pressure, temperature, and back pressure
3	H_0	At 2	Base initial enthalpy, Btu per lb
4		Fig. 1 at 3	Base initial w/p
5	SR_1	Given	Base nonextraction steam rate, lb per kwhr
6		Fig. 5	Base "Equivalent Final Pressure" of feedwater, psia
7	hf	At 6	Base final enthalpy of feedwater, Btu per lb
8		3 — 7	Base heat added in boiler, Btu per lb
9		Given	Heat rate at base condition, Btu per kwhr
10		Given	New initial pressure, temperature and back pressure
11	H_0	At 10	New initial enthalpy
12		Fig. 1 at 11	New initial w/p
13		At 10	Steam rate correction factor for pressure
14		At 10	Steam rate correction factor for temperature
15		At 10	Steam rate correction factor for back pressure
16		13 × 14 × 15	Combined steam rate correction factor
17		4/12	Inverse ratio of w/o
18		6 × 16 × 17	New "Equivalent Final Pressure" of feedwater, psia
19	h_f	At 18	Final enthalpy of feedwater, Btu per lb
20		11 — 19	Heat added in boiler, Btu per lb
21		20/8	Direct ratio of heat added in boiler
22		9 × 16 × 20	Corrected heat rate, Btu per kwhr
23	F_T	22 × Load/20	Throttle flow with feedwater heating, lb per hr
24	hc	At 2	Enthalpy of liquid at back pressure, Btu per lb
25		19 — 24	Actual heat rise of feedwater, Btu per lb
26		Fig. 4 at 25	Total extraction as per cent of throttle flow
27		23 × 26/100	Total extraction flow, lb per hr
28	F_c	23 — 27	Flow to condenser, lb per hr

TABLE 1 — COMPARISON BETWEEN INITIAL AND FINAL w/p VALUES

Initial and final pressures	600 psig — 50 psig			600 psig — 100 psig		
		Base			Base	
Initial temperature, deg F	750	825	900	750	825	900
Theoretical steam rate, lb per kwhr	15.36	14.31	13.38	19.44	18.05	16.87
Initial enthalpy, Btu per lb	1379.0	1420.9	1461.9	1379.0	1420.9	1461.9
Used energy, Btu per lb	177.8	190.8	204.0	140.5	151.3	161.8
Final enthalpy, Btu per lb	1201.2	1230.1	1257.9	1238.5	1269.6	1300.1
Initial w/p, Fig. 1	43.4	41.9	40.5	43.4	41.9	40.5
Final w/p, Fig. 1	52.9	50.9	49.2	50.4	48.5	46.9
Ratio of initial w/p	1.036	1.00	0.967	1.036	1.00	0.967
Ratio of final w/p	1.040	1.00	0.967	1.039	1.00	0.967

TABLE 2 — STEAM RATE CORRECTION FACTORS FOR INITIAL PRESSURE WITH CONSTANT INITIAL TEMPERATURE

	2000 kw to 15,000 kw					
Design initial pressure, psig	400		500		600 and Above	
Differential pressure	−10%	+10%	−10%	+10%	−50 lb	+50 lb
Correction factor	1.005	0.995	1.004	0.996	1.002	0.998

stage enthalpy when correcting stage pressure with constant flow to the following stage. Hence, stage pressure varies inversely as the initial w/p, and this value is readily determined from Fig. 1 at the initial enthalpy. This procedure is used in Parts 1 and 3.

Part 2, "Derivation of Heat Rate Correction Factors for Back Pressure", is expanded to include throttle flow and condenser flows corresponding with the new heat rates. Lines 9 to 24 are repeated for each back pressure.

When turbine-generator heat rates and condenser flows at different back pressures are available, the performance of the turbine and condenser as a unit can be estimated. Condenser performance can be estimated quickly if only two items are known, namely: (a) circulating water inlet temperature, and (b) condenser pressure at a given value of steam condensed.

On a curve with steam condensed as the ordinate and saturation temperature of steam in the condenser as the abscissa, Fig. 2, plot the circulating water inlet temperature at zero steam condensed. Then at the given quantity of steam condensed, (say at 4/4 load at the base back pressure), plot the saturation temperature corresponding to the given base back pressure. Draw a straight line through these two points. This line is a close approximation to the condenser characteristic with variation in quantity of steam condensed, except at low flows. In the latter region, the actual performance curve will diverge from the straight line, as some temperature head must be available for heat transfer. Condenser performance at other circulating water temperatures can be esti-

TABLE 3—STEAM RATE CORRECTION FACTORS FOR TEMPERATURE

2000 kw to 15,000 kw

Design initial pressure, psig	400		800		1200	
Temperature change, deg F	−25	+25	−25	+25	−25	+25
Design initial superheat, deg F						
0	—	0.974	—	0.967	—	0.958
25	1.025	0.975	1.030	0.970	1.035	0.965
50	1.024	0.976	1.028	0.972	1.030	0.970
100	1.024	0.976	1.026	0.974	1.027	0.973
150	1.023	0.977	1.024	0.976	1.025	0.975
200	1.022	0.978	1.023	0.977	1.024	0.976
250	1.021	0.979	1.022	0.978	1.023	0.977
300	1.020	0.980	1.020	0.980	1.021	0.979
400	1.018	0.982	1.018	0.982	1.019	0.981

EXAMPLE OF PART 2 FOR A 10,000 KW, 60 CYCLE TURBINE-GENERATOR

600 psig—825 F

Line	Symbol	Source	Numerical values				
1		Given	2500	5000	7500	10,000	12,500
2	H_o	Given	1420.9	1420.9	1420.9	1420.9	1420.9
3		Given	1.5	1.5	1.5	1.5	1.5
4	SR_1	Given	10.37	9.01	8.62	8.48	8.49
5	p	Fig. 5	31.25	62.5	93.75	125.0	156.2
6	h_{f1}	At S	221.2	264.8	293.5	315.8	334.0
7		2 − 6	1199.7	1156.1	1127.4	1105.1	1086.9
8	HR_1	Given	13,030	11,190	10,650	10,450	10,440
9		Select	1.0	1.0	1.0	1.0	1.0
10		At 9	0.9618	0.9715	0.9805	0.989	0.9903
11	SR_2	4 × 10	9.97	8.75	8.45	8.39	8.41
12		5 × 10	30.1	60.8	92.0	123.6	154.7
13	h_{f2}	At 12	218.9	263.0	292.1	314.8	333.2
14		6 − 13	2.3	1.8	1.4	1.0	0.8
15		1 + (14/7)	1.002	1.002	1.001	1.001	1.001
16	HR_2	8 × 10 × 15	12,560	10,890	10,450	10,350	10,340
17		10 × 15	0.964	0.973	0.982	0.990	0.991
18		7 + 14	1202.8	1157.9	1128.8	1106.1	1087.7
19	F_T	16 × Load/18	26,100	47,000	69,450	93,600	118,800
20	h_c	At 9	47.1	47.1	47.1	47.1	47.1
21		13 − 20	171.8	215.9	245.0	267.7	286.1
22		Fig. 4 at 21	16.2	20.0	22.3	24.2	25.6
23		19 × 22/100	4200	9400	15,500	22,700	30,400
24	F_c	19 − 23	21,900	37,600	53,950	70,900	88,400
9		Select	2.0	2.0	2.0	2.0	2.0
10		At 9	1.043	1.036	1.0317	1.0285	1.0265
11	SR_2	4 × 10	10.82	9.34	8.89	8.72	8.72
12		5 × 10	32.6	64.8	96.7	128.5	160.5
13	h_{f2}	At 12	223.6	267.2	295.8	318.2	336.2
14		6 − 13	−2.4	−2.4	−2.4	−2.4	−2.2
15		1 + (14/7)	0.998	0.998	0.998	0.998	0.998
16	HR_3	8 × 10 × 15	13,570	11,570	10,960	10,740	10,700
17		10 × 15	1.041	1.034	1.030	1.027	1.025
18		7 + 14	1197.3	1153.7	1125.0	1102.7	1084.7
19	F_T	16 × Load/18	28,400	50,200	73,100	97,300	123,300
20	h_c	At 9	69.1	69.1	69.1	69.1	69.1
21		13 − 20	154.5	198.1	226.7	249.1	267.1
22		Fig. 4 at 21	14.7	18.4	20.9	22.7	24.2
23		19 × 22/100	4200	9250	15,300	22,100	29,800
24	F_h	19 − 23	24,200	40,950	57,800	75,200	93,500

TABLE 4—STEAM RATE CORRECTION FACTORS FOR BACK PRESSURE

2000 kw to 15,000 kw

To determine steam rates for operation at a back pressure other than design back pressure, multiply straight condensing steam rates at design back pressure by factors listed below, interpolating if necessary

1.5 in. Hg absolute design back pressure

Rated load steam rate	Load	Operating back pressure, in. Hg absolute 0.50	1.0	1.25	1.50	1.75	2.0	2.5
8	1/4	0.931	0.963	0.981	1.000	1.021	1.041	1.078
	2/4	0.951	0.972	0.986	1.000	1.018	1.035	1.067
	3/4	0.966	0.981	0.990	1.000	1.015	1.031	1.059
	4/4	0.981	0.990	0.995	1.000	1.014	1.028	1.054
	5/4	0.985	0.991	0.996	1.000	1.013	1.026	1.051
10	1/4	0.929	0.958	0.978	1.000	1.025	1.049	1.096
	2/4	0.950	0.970	0.984	1.000	1.020	1.039	1.076
	3/4	0.964	0.979	0.989	1.000	1.017	1.034	1.066
	4/4	0.975	0.986	0.993	1.000	1.015	1.030	1.060
	5/4	0.980	0.988	0.994	1.000	1.014	1.028	1.056

2.0 in. Hg absolute design back pressure

Rated load steam rate	Load	Operating back pressure, in. Hg absolute 1.0	1.5	1.75	2.00	2.25	2.5	3.0
8	1/4	0.941	0.970	0.985	1.000	1.017	1.033	1.064
	2/4	0.956	0.977	0.988	1.000	1.014	1.028	1.054
	3/4	0.968	0.983	0.991	1.000	1.013	1.025	1.047
	4/4	0.977	0.988	0.994	1.000	1.011	1.022	1.043
	5/4	0.981	0.990	0.995	1.000	1.010	1.020	1.040
10	1/4	0.930	0.964	0.982	1.000	1.020	1.040	1.077
	2/4	0.946	0.972	0.986	1.000	1.016	1.032	1.062
	3/4	0.958	0.978	0.989	1.000	1.014	1.028	1.054
	4/4	0.965	0.981	0.991	1.000	1.012	1.024	1.047
	5/4	0.971	0.985	0.992	1.000	1.012	1.023	1.046

2.5 in. Hg absolute design back pressure

Rated load steam rate	Load	Operating back pressure, in. Hg absolute 1.0	1.5	2.0	2.5	3.0	3.5	4.5
8	1/4	0.925	0.949	0.975	1.000	1.028	1.055	1.099
	2/4	0.943	0.959	0.979	1.000	1.024	1.046	1.081
	3/4	0.958	0.970	0.985	1.000	1.020	1.039	1.069
	4/4	0.967	0.976	0.987	1.000	1.019	1.036	1.062
	5/4	0.971	0.979	0.989	1.000	1.018	1.035	1.061
10	1/4	0.912	0.941	0.971	1.000	1.034	1.066	1.118
	2/4	0.934	0.955	0.977	1.000	1.027	1.053	1.096
	3/4	0.949	0.964	0.982	1.000	1.023	1.046	1.083
	4/4	0.960	0.971	0.985	1.000	1.022	1.044	1.080
	5/4	0.966	0.975	0.987	1.000	1.022	1.044	1.080

3.0 in. Hg absolute design back pressure

Rated load steam rate	Load	Operating back pressure, in. Hg absolute 1.0	2.0	2.5	3.0	3.5	4.0	5.0
8	1/4	0.919	0.959	0.979	1.000	1.025	1.050	1.088
	2/4	0.937	0.966	0.983	1.000	1.021	1.041	1.071
	3/4	0.954	0.974	0.986	1.000	1.018	1.035	1.060
	4/4	0.966	0.979	0.989	1.000	1.016	1.031	1.054
	5/4	0.972	0.982	0.990	1.000	1.016	1.031	1.054
10	1/4	0.897	0.948	0.974	1.000	1.031	1.060	1.105
	2/4	0.924	0.960	0.979	1.000	1.024	1.047	1.084
	3/4	0.942	0.968	0.983	1.000	1.022	1.041	1.072
	4/4	0.958	0.976	0.987	1.000	1.021	1.039	1.067
	5/4	0.964	0.979	0.989	1.000	1.021	1.039	1.067

mated by drawing straight lines from the new temperatures at zero steam condensed and parallel to the original curve. See Fig. 2.

Data from the turbine heat rate calculation at variant back pressure may now be plotted on the condenser performance curve. For example, at 4/4 load plot flow to condenser against saturation temperature corresponding to its back pressure for each 4/4 load point. Then the intersection of a curve through these points and a line of constant circulating water temperature indicates saturation temperature of the steam in the condenser. This value is convertible to back pressure by means of auxiliary curve, which simultaneously satisfies both turbine and condenser data at this load. Similar curves and derived information can be worked up for other generator loads, thereby showing turbine-condenser relationship at any circulating water temperature.

Throttle flow corresponding to any selected steam flow to the condenser from Fig. 2 can be found from Fig. 3, which is a plot of data accumulated in the back pressure correction calculation. For each load, plot condenser flow vs throttle flow for the different back pressures. The proper load curve can be entered at the condenser flow found from Fig. 2 to obtain the corresponding flow to throttle.

This is particularly useful when estimating maximum flow required from the boiler at maximum turbine output. For instance, at the highest expected circulating water temperature, draw a line parallel to the base circulating water temperature line on Fig. 2. The intersection of this line with the maximum load line for the turbine gives condenser flow, and at this value read the maximum throttle flow on Fig. 3.

Some generalizations regarding heat rate and steam rate can be made from an inspection of the figures in the attached examples. These are:

1. Change of initial pressure. Change in heat rate is greater than the change in steam rate, although both changes are relatively small.

2. Change of initial temperature. Change in heat rate is less than one-half the change in steam rate.

3. Change of back pressure. Change in heat rate is slightly less than the change in steam rate.

No example is included for Part 3 as it is a combination of Parts 1 and 2 and its use should be apparent.

STEAM RECIRCULATION

Heat transfer efficiency for installations using steam as the heating medium in closed surfaces frequently can be improved by utilizing recirculation. This article presents basic factors for the practical application of steam recirculation systems

LEO WALTER, *Consulting Engineer*

SEVERAL steam recirculation systems can be utilized by engineers dealing with manufacturing processes. Principal applications are plastic presses or other machines having horizontal heating surfaces where gravity condensate movement is apt to be sluggish. In some instances, small diameter steam heated rollers or cylinders might lend themselves to the use of steam recirculation. This article details basic considerations for practical application of steam recirculated by means of special nozzles.

Heat Transfer

When steam is used as a heating medium in closed surfaces, the rate of heat input to the material being heated depends partially on keeping the surface in contact with the material at a temperature as near as possible to that of the steam. In other words, the temperature difference between the steam and the outside of the heating surface should be as low as possible. To accomplish this, the heat from the steam must pass through any heat flow resisting films of condensate and air, then through the metal wall. The metal wall of the steam space is a good conductor of heat, but air and condensate are poor conductors and seriously retard heat flow.

Effect of Flow Pattern

To obtain minimum temperature drop, it is obvious that air and condensate films must be reduced to the minimum thickness or in some way induced to conduct heat more rapidly than they

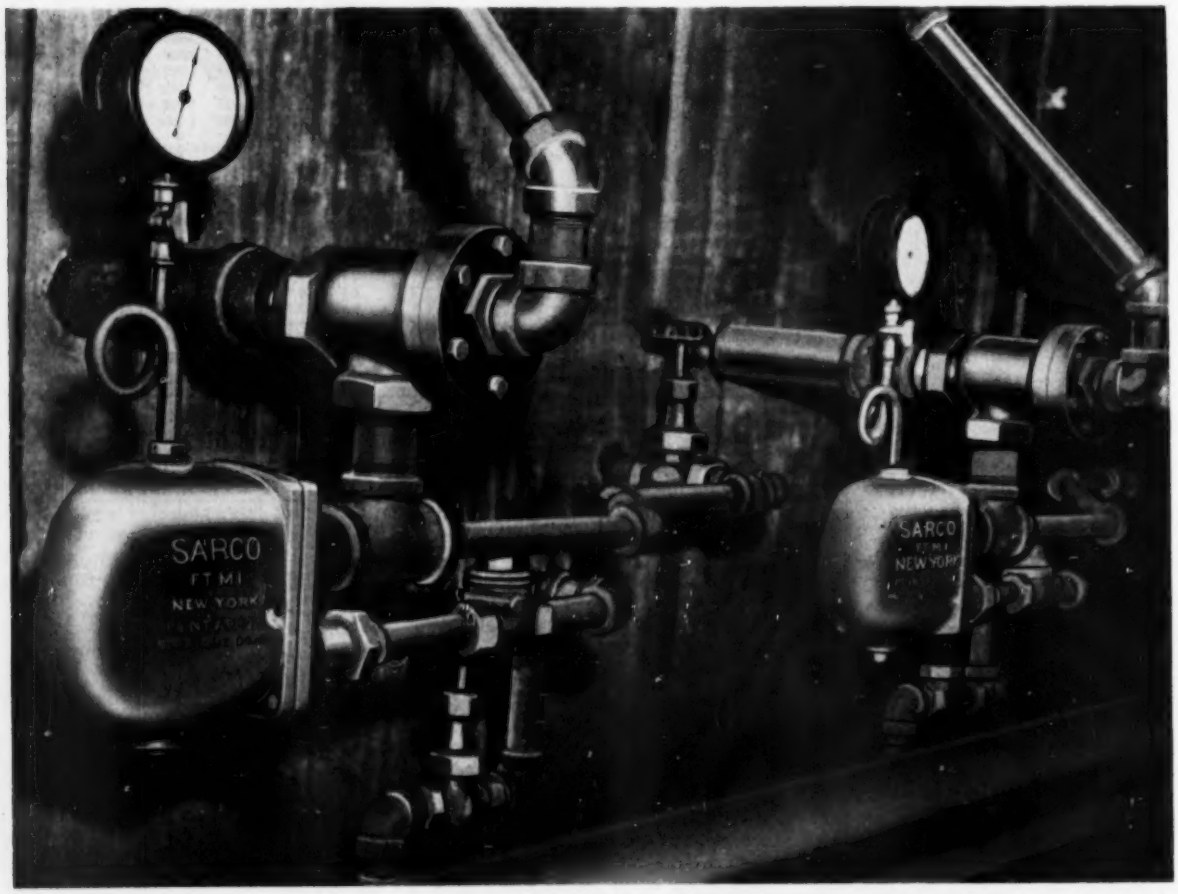


Photo shows part of a typical steam circulation system serving a piece dryer in a textile plant. This installation increased output by raising the air temperature from 240 to 290 F

normally would if stagnant. When steam is flowing over a heated surface, it tends to drag the surface of the condensate film along with it. Thus, if steam and condensate are flowing in the same direction, condensate is helped along towards the outlet and the average film thickness is reduced. This helps to improve heat transfer. Velocities of both steam and condensate are therefore very important, but another factor that is also very important is the way condensate and air films flow over the heated surface.

When fluids such as steam, air or water are flowing in pipes or across plane surfaces, flow may be quite smooth if the velocity is low, or rough and disturbed if the velocity is high.

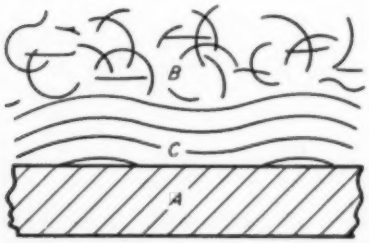


Fig. 1—Example of streamline flow

The smooth kind is referred to as "streamline flow" while the rough type is called "turbulent flow." The speed at which a change from streamline to turbulent flow occurs depends on the nature of the fluid and its depth, but for a given fluid at a given temperature, pressure and depth, the change occurs at a certain velocity.

Streamline Flow

Fig. 1 shows a heating surface A that may be the wall of a pipe through which steam B is flowing slowly and condensing. Condensate C flows in the same direction and mixes with air to form an air-condensate film, which resists heat flow from steam B to the heated wall A. As movement of the air-condensate film is slow (streamline), the particles tend to follow straight lines and heat absorbed by the layer nearest the steam does not mix much with the other particles. Heat must, therefore, be passed from particle to particle across the fluid stream. Since the fluid stream is a poor conductor, the process is comparatively slow and depends on drop in temperature.

Turbulent Flow

If the speed of the steam B is increased, flow rate of the air-condensate film will also increase. When the film speed reaches a velocity where flow becomes turbulent as shown in Fig. 2, the air-condensate particles mix up rapidly as they flow along. A particle may absorb heat from the steam and a moment later be swept to the heated wall to give up its heat rapidly. Of course, heat is carried by conduction but the mechanical movement of the fluid in a turbulent flow stream improves heat transfer rate. This is one

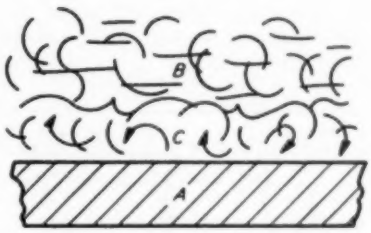


Fig. 2—Example of turbulent flow

reason why heat transfer through vertical steam heated surfaces is greater than that through horizontal surfaces, and why it helps to keep steam and condensate flowing in one direction.

Many steam plant operators say that by opening the by-pass around a steam trap they are able to increase output. Although in many cases this is largely imagination, it can well be understood that if blowing steam to waste through the by-pass increases steam velocity sufficiently then the effect previously described will be achieved. For example, assume the steam line shown in Fig. 3 is two inches in diameter and 100 ft long. Steam is admitted from the main A at 120 psig through valve B to the pipe inlet C, at which point pressure has dropped to 100 psig due to friction in valve B. Since one pound of steam at 100 psig pressure occupies 3.8 cu ft, if steam consumption is 500 lb per hr the volume passing section C will be 500 x 3.8 =1900 cu ft per hr. This means that steam velocity through the 2 in. pipe at C is 24 fps. By the time the steam reaches point D, one half of the steam has condensed, and velocity is reduced to 12 fps. At E, the end of the pipe immediately before steam trap F, all the steam will have condensed so velocity will be zero. Thus mean steam velocity in this pipe at the assumed operating conditions is 12 fps.

Effect of Increased Velocity

Now assume the trap by-pass valve G is opened and steam is discharged at the rate of 500 lb per hr. Then at point C there will be 500 lb per hr passing into the pipe to be condensed plus 500 lb per hr which will pass through the pipe and by-pass to waste, making 1000 lb per hr total. This volume will increase the velocity at C to 48 fps. At D one half of 500 lb per hr will have condensed, leaving 750 lb per hr passing this point at a velocity of 36 fps. At point E, 500 lb of steam per hr will have condensed, but

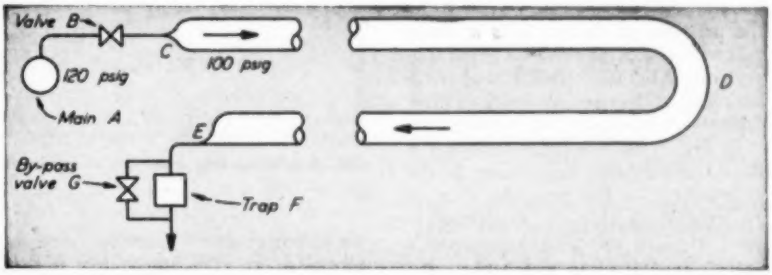


Fig. 3—Typical arrangement of simple steam pipe for process heating application

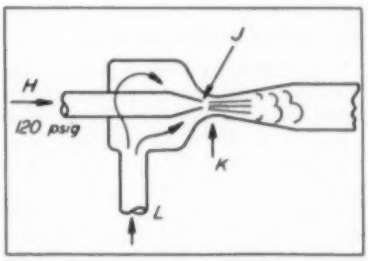


Fig. 4—Principle of thermo compression

500 lb per hr will be passing to waste and velocity will be 24 fps instead of zero. Mean velocity in the pipe as a result of passing twice the quantity of steam into it will therefore be trebled, increasing from 12 to 36 fps. With a velocity increase of this magnitude, it is more than probable that the air-condensate flow pattern will change from streamline to turbulent, especially if the pipe has appreciable length.

Steam Circulation

Primarily, the object of steam circulation is to give maximum possible

velocity through the steam space while eliminating the waste that occurs with open by-pass valves. Simply increasing the steam velocity, however, does not necessarily increase the rate of heat transfer. It is important that the increased velocity must take effect on the air-condensate film at the heated surface and this can only be done satisfactorily if heating surfaces of comparatively small area are used.

Function of Circulators

Referring again to Fig. 3, the reason why steam flows from point C to point E is that, due to condensation, the pressure at E is slightly lower than at C. Fluids will always flow from a region at one pressure to another at a lower pressure. Since steam flow velocity depends on the difference in pressure, the pressure differential must be increased if higher velocity is desired. If this effect is to be produced by passing excess steam through the pipe from C to E and then reintroducing it at C, there must be some means of increasing the pressure of the steam as it leaves point E so that re-entry at point C is possible. This is the function of circulators, or as they are sometimes called, "thermo-compressors" or "ejectors."

In Fig. 3, the line pressure shown at A is 120 psig and the pressure at the pipe inlet C is 100 psig, the drop of 20 psig being due to throttling in valve B. This throttling represents a certain amount of wasted energy, and it is this energy which is used in the circulator to compress excess steam taken from the outlet for reintroduction at the inlet.

Operation of Circulators

Fig. 4 shows a diagrammatic section of a steam ejector or thermo-compressor where steam at say 120 psig pressure enters at H and passes through nozzle J into combining cone K which is assumed to be at a pressure of 99 psig. The effect of passing the steam through the nozzle J into the lower pressure region at K is to increase its velocity considerably so that while the same weight of steam is passing through J in a given time as through the larger pipe H, its speed is much greater at J than at H.

Inlet L is connected to the outlet from the steam space, which in the case of Fig. 3 is at E. Particles of steam that have passed through the pipe enter at L and as soon as they reach the combining cone K they are immediately struck by high speed particles of fresh steam. This increases the speed of the excess steam particles and decreases the velocity of the live steam particles. Immediately after passing through the throat K, the pipe section is enlarged so that the combined excess and makeup steam can spread as well as move forward, thereby reducing the speed of the mixture. As speed is reduced, pressure begins to build up, and the greater the pressure differential between point H and nozzle outlet J the faster will the makeup steam move and the more violently will its particles strike the particles of excess steam returning to be recompressed. Obviously, if there is no difference in pressure between H and K then there will be no increase in velocity and there can be no recompression. Therefore, one essential of a circulating system is that there must be some drop in pressure between supply line and steam space.

Pressure Required

Generally, a pressure of not less than 10 to 20 psig is required. If the pressure drop is less than this, the quantity of steam circulated will be small, and if the pressure drop is very great, complications may arise in making the steam nozzle small enough for the load. While efficient circulator operation depends on the design of the ejector itself, one even more important factor is to make sure that the job to which it is applied is suitable for utilization of recirculation.

System Arrangement

Fig. 5 illustrates a complete circulating system. Steam from main M passes through a stop valve N and reducing valve O into circulator P. From P it flows through heating surface Q into separator R at which point steam is recirculated to P through pipe S. Condensate is discharged from the separator by steam trap T. The reducing valve O is not absolutely necessary and, if used, should be of the relay type with the relay connection taken from steam space Q. Then when the load at Q varies, reducing valve O will correct any pressure difference by controlling supply pressure to circulator P.

Steam Space Construction

The internal construction of the steam space actually determines the effectiveness of increased steam velocity at the heated surface. For example, if two simple pipe heaters are supplied with steam at the same pressure and have the same heating surface, steam consumption will be identical for both units even though one is constructed of 2 in. pipe and the other of 6 in. pipe. But, due to the greater cross-sectional area of the 6 in. pipe, mean steam velocity will be nine times as great in the 2 in. pipe as in the 6 in. pipe. With this condition, it is obvious that if the velocity in both pipes were increased by the same amount, the effect of steam flow on speed near the heating surface would be much less in the 6 in. pipe than in the 2 in. pipe. Carrying this concept still further and thinking in terms of a 5 ft diam cylinder, it can be seen that velocity across the cylinder from inlet to outlet could be increased considerably without having the slightest effect on steam speed near to the heated surface. Thus, when steam circulation is being considered, it is extremely important to find out what the internal construction of the steam space is like.

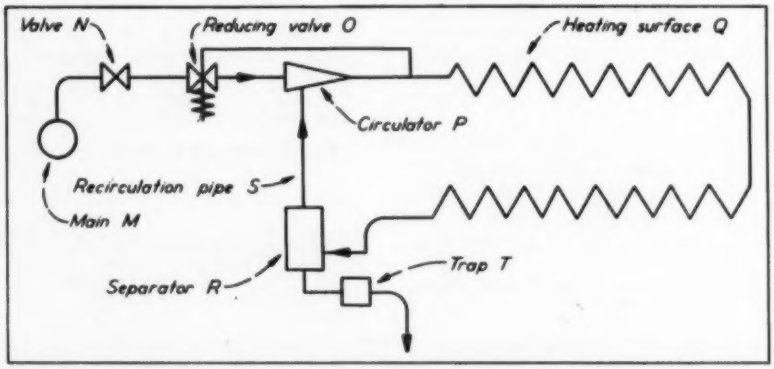


Fig. 5—Schematic diagram of recirculation system applied to steam heating coil

System Resistance

An important factor when designing a steam circulating system is the size, length and number of obstructions in the connecting piping between the excess steam outlet from the steam space and the recompressed steam inlet. Units constructed of long small bore pipes with numerous bends or fittings have high resistance to steam flow. Since pressure drop in a pipe line increases as the square of the

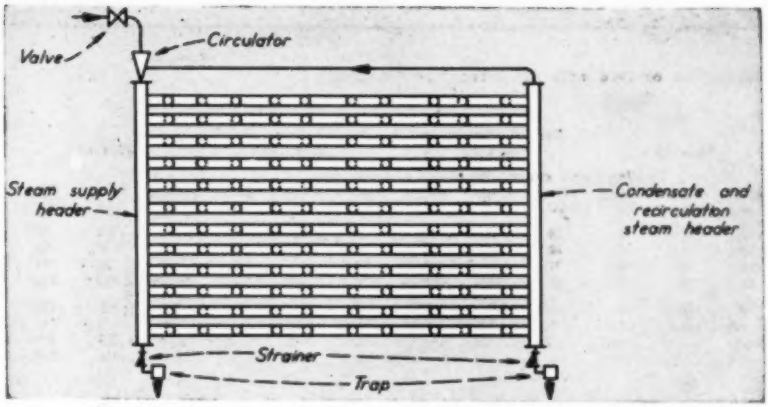


Fig. 6—Recirculation system installed on the heating coils of a textile dryer

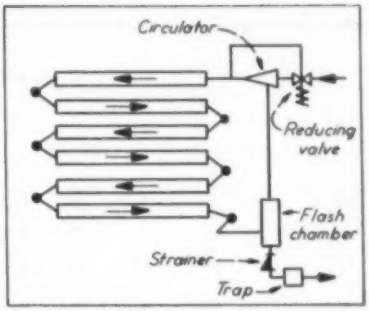


Fig. 7—Steam recirculation on plastic press with series platen connections

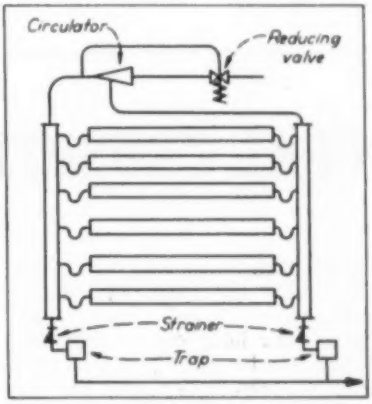


Fig. 8—Steam recirculation on plastic press with parallel platen connections

velocity, when velocity is doubled the pressure drop increases four times, and the loss must be made up by work done in the steam circulator. This imposes unnecessary load on the circulator as its real function is to overcome only the frictional loss in the steam space where the useful effect of increased velocity is needed.

Individual Circulation

Steam circulation across a group of steam heated machines or sections of machines may reduce but will not eliminate the adverse effects of group trapping. The probability of short circuiting steam through a machine or section which offers less resistance to steam flow than the rest still remains. This fact makes individual steam recirculation advantageous. Some manufacturers ignore this completely and offer group steam circulation for, say, a complete 8 roll ironer in a laundry, or for multicylinder textile dryers. It is safe to say, however, that steam circulation should be applied to each section of a multisection machine in the same manner traps are utilized. Of course, there may be exceptions where the cost of individual circulation on each section of some machine would not be justified. The technical principle remains sound, however, and on such applications proper engineering must be evaluated against the cost. In the examples which follow it will be seen how some steam spaces lend themselves immediately to steam circulation, others require modifications, and some are not suitable.

Suitable Applications

Many steam heated machines are constructed of pipes or have internal passages resembling steam pipes. Examples are textile tentering and carbonizing machines as shown in Fig. 6, heated presses, tray dryers, and still heating coils. Because the tubes are horizontal and sometimes of considerable length, often condensate does not flow readily by gravity to the discharge connection at the trap. On such machines, increasing the steam velocity tends to sweep both condensate and air towards the outlet.

Series Steam Connections

Fig. 7 shows a plastic press with series steam connections on the platens, which consist of steel plates with steam passages drilled in them. Steam flows through the platens to a flash vessel, which allows accumulation of condensate that is drained by a steam trap. Flash steam and excess steam that has not been condensed is drawn into the circulation nozzle. Live steam enters through the reducing valve A, which has an impulse line connected to the mixed steam section.

Parallel Steam Connections

Steam flow in the plastic press shown in Fig. 8 is in parallel through the platens, and recirculation is taken from the top of the outlet header. In this case, mixed steam enters the press via the inlet header. It is important to trap both headers as shown.

In general, the success of steam circulation systems in reducing insulating effects of stagnant condensate-air films on condensing surfaces and thereby considerably increasing efficiency of heat transfer from the steam, depends largely on the shape and volume of the steam space in relation to the velocity of the steam feeding it. Usually, these systems are excellent for applications where the cross-sectional area of the steam space is comparable with the cross-sectional area of the steam inlet. Much of their useful effect is lost, however, where the steam space is of much larger area than the inlet: for example, in a drying cylinder or similar application.

One point that should be clearly understood is the method of employing steam circulation systems on a group of units or several parts of one unit. If the units or separate steam spaces are in series, steam circulation generally can be applied successfully: for example, in many kinds of plastic presses. In such cases, the area of the steam space is unaffected.

If the units are connected in parallel there may be difficulties. When steam spaces are paralleled, the cross-sectional area increases accordingly and may then be much greater than the steam inlet area itself. In such cases, there is a danger that individual control of each unit may be lost. Parallel installations usually have either constant circulation and no control, or control and no constant circulation. Circulated steam will always take the easiest way, and with such parallel arrangements, it is possible that the difficulties associated with group trapping could arise and nullify any possible advantage of steam circulation. To be entirely effective on parallel groups of units the system must, in the majority of cases, be applied to each unit of a group so that there is both constant circulation and individual control of the operation of each unit.

TABLE 1—CAPACITIES OF TWO ROLL CRUSHERS, TON PER HOUR

Size of product		Size of crusher, in. 20 x 18			20 x 24			26 x 24			26 x 30			28 x 24		
		Grade of coal and maximum size of lumps, in.														
Screen or ring, in.	Cube in.	Hard 6	Med. 8	Soft 10	Hard 6	Med. 8	Soft 10	Hard 12	Med. 14	Soft 16	Hard 12	Med. 14	Soft 16	Hard 14	Med. 16	Soft 18
1½	1	30	40	50	40	50	60	50	65	80	65	80	100	50	65	80
1⅝	1⅛	35	45	55	50	60	70	60	75	90	75	95	115	60	75	90
2	1⅜	40	50	60	50	65	80	70	85	100	90	105	125	70	85	100
3	2	50	65	80	70	90	110	85	105	125	105	135	160	90	110	130
4	2¾	70	85	100	90	115	140	110	140	170	140	175	215	115	145	175
5	3½	...	...	...	...	...	...	140	175	210	175	220	265	145	180	215
6	4	...	...	...	...	...	...	...	...	...	...	...	...	170	210	250
8	5½	...	...	...	...	...	...	...	...	...	...	...	...	210	265	320
Rpm of roll			130			130			120			120			115	
Motor hp			7½			10			15			15			15	

COAL CRUSHERS . . . Types and Classifications

- Four major types of coal crushers are compared
- Limitations and advantages of each are given
- Tables illustrate capacities and horsepower ratings

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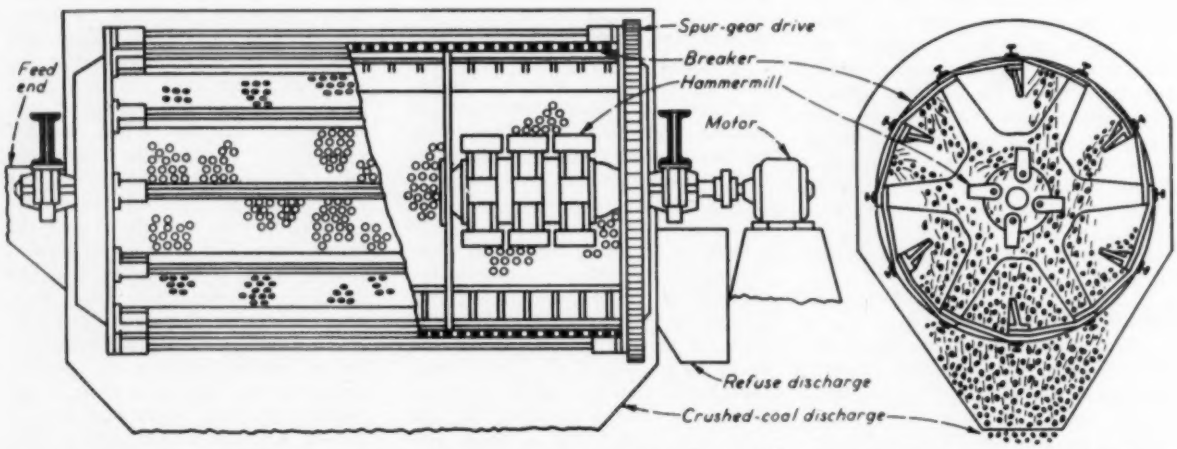
USUALLY coal crushing requirements are satisfied by a double roll or a single roll crusher. Either will reduce lump coal to a product, which may be called ¾ x 0-in. or if need be, down to ½ x 0-in. The two-roll machine cracks the lumps between toothed rolls. The single roll pinches the coal between a toothed roll and an adjustable plate. When desirable to have a uniform product-size with the minimum of undersize, the former would seem to be better, but actual tests have shown there is little difference between the two. The double roll crusher has the advantage of digesting large lumps, which cannot be gripped by a single roll. An advantage of the single roll crusher is that adjustments may be made while running, simply by changing the clearance between the fixed plate and the roll. However, some of the double roll crushers are now available that permit easy adjustment of rolls to change the coal size.

Low Speed Breakers

A more costly unit is the Bradford breaker. It is a slow speed (25 rpm or less), rugged machine with remarkably low upkeep cost and low power requirement per ton per hour. Essentially it is a *squirrel cage* with circumferential perforated plates through which the undersize passes, and with internal deflector shelves, which lift and drop the oversize as the mass drifts toward the far end. Of prime importance is that the breaker



Breaker hammermill is mounted concentrically on the discharge end spider, which has an extended hub with two anti-friction bearings forming a quill for the shaft. Breaker turns at 25 rpm, while motor speed is 720 rpm

TABLE 1 — CAPACITIES OF TWO ROLL CRUSHERS, TON PER HOUR

Size of crusher, in.																	
30 x 24			30 x 30			30 x 36			30 x 48			36 x 36			Size of product		
Grade of coal and maximum size of lumps, in.																	
Hard 14	Med. 16	Soft 18	Hard 14	Med. 16	Soft 18	Hard 14	Med. 16	Soft 18	Hard 14	Med. 16	Soft 18	Hard 16	Med. 18	Soft 20	Screen or ring, in.		Cube in.
55	70	85	70	90	110	80	105	130	110	140	175	90	110	130	1½		1
65	80	100	80	100	120	100	125	145	130	165	195	100	125	150	1¾		1⅛
75	90	110	95	115	135	115	140	160	150	185	215	115	145	175	2		1⅜
100	120	140	120	150	175	145	180	210	195	235	280	150	185	220	3		2
125	155	190	150	195	235	185	235	285	250	315	375	195	240	290	4		2¾
155	195	230	195	240	290	235	290	350	315	385	465	240	300	360	5		3½
185	225	270	230	280	335	275	340	405	385	450	535	280	350	420	6		4
225	285	345	280	355	430	340	425	515	460	570	690	355	445	535	8		5½
	115			115			115			115			110			Rpm of roll	
	15			20			20			25			30			Motor hp	

will cull out rags, wire, straw, and tramp iron, something the roll crushers cannot do. The breaker is not so good when there are frequent size changes since all the plates must be changed.

When the coal is very hard, with lumps that will not fracture by the drop from the lifting shelves, a hammermill is mounted in the far end of the cage. This combination permits the use of a smaller diameter breaker for a given capacity. The hammermill is specified for a product smaller than can be secured by the roll crushers or breaker. Essentially it is a high speed unit with some form of slugger hammers attached to a rotor that shatters or grinds the coal against a bar-screen cage.

Spacing of the bars determines the product, specifically, the maximum lump. Usually a trap or pocket culls out material that cannot be shattered by impact. Straw, hay, and similar materials are ground up. When coal is to be passed on to pulverizers, as with pulverized fueled boilers, the hammermill has the advantage that it will produce a product best suited to final reduction.

Precautions

In general, heavy duty roll crushers should have large diameter, short rolls. The crusher is more liable to damage than other elements of a material handling system and should be located so that repairs can be made readily. That some oversize will be found in the output of roll crushers is to be expected, so a fair specification is that not more than 10 per cent shall be oversize.

Crushed coal is expressed in terms of the size of screen through which it will pass, thus *minus 4 in.* means it will pass through a 4 in. screen. 4-in. x 2-in. gives the maximum and minimum size of the product. Stating whether a reference is to lump size or the screen through which it will pass is necessary. Thus, a 1 in. cube is equivalent to 1½ in. ring size; a

TABLE 2—CAPACITIES OF SINGLE ROLL CRUSHERS, TON PER HOUR

Size of product		Size of crusher, in.																		
		24 x 24			24 x 30			24 x 36			30 x 24			30 x 30			30 x 36			30 x 42		
		Grade of coal and maximum size of lumps, in.																		
Screen or ring, in.	Cube in.	Hard 14	Med 16	Soft 18	Hard 14	Med 16	Soft 18	Hard 14	Med 16	Soft 18	Hard 16	Med 18	Soft 20	Hard 20	Med 22	Soft 24	Hard 20	Med 22	Soft 24	Hard 20	Med 22	Soft 24
		10	20	25	10	25	30	15	30	40	25	35	45	30	45	50	35	55	70	45	65	85
1¼	⅞	25	40	50	30	50	60	40	60	75	45	75	105	50	95	135	70	115	165	85	135	190
		15	25	30	15	30	35	20	35	45	30	45	55	35	50	60	40	65	80	50	75	95
1½	1	30	50	60	35	60	75	45	75	90	55	90	125	60	110	155	80	130	185	95	155	215
		20	30	40	25	35	50	30	45	60	35	50	60	40	60	75	50	75	90	55	85	105
1⅝	1⅛	40	60	75	50	75	95	60	90	110	60	100	140	75	125	175	90	150	210	105	175	245
		25	35	50	30	45	65	40	50	75	40	60	70	50	75	100	60	90	120	70	110	140
2	1⅜	50	75	100	65	95	125	75	110	150	70	130	160	100	160	200	120	195	240	140	230	280
		30	50	60	35	65	75	45	75	90	45	75	105	60	90	130	70	110	155	85	130	180
3	2	60	95	130	75	120	110	90	145	195	105	150	215	130	195	265	155	225	300	180	270	360
		35	55	60	45	70	85	50	85	100	55	85	115	65	110	150	80	130	180	95	155	205
4	2¾	60	105	145	85	130	180	100	160	215	115	175	235	150	220	295	180	265	350	205	310	410
		40	60	70	50	75	90	60	90	105	60	95	130	70	120	165	85	145	200	100	170	235
5	3½	70	120	165	90	150	205	105	180	250	130	190	265	165	240	330	200	290	395	235	335	465
		45	65	75	55	80	95	65	95	115	65	105	140	75	130	175	90	155	210	110	180	245
6	4	75	130	175	95	165	220	115	195	265	140	205	285	175	255	355	210	305	425	245	355	500
		50	70	95	60	85	120	70	105	145	75	135	155	90	165	190	110	200	235	135	230	275
8	5½	95	150	190	120	190	240	145	225	285	155	230	345	190	295	430	235	350	515	275	405	600
Minimum size of motor, hp			10			10			15			15			20			25			25	
		Std		Max	Std		Max	Std		Max	Std		Max	Std		Max	Std		Max	Std		Max
Rpm of roll		60		100	60		100	60		100	50		75	50		75	50		75	50		75

3½ in. lump to a 5 in. ring size.

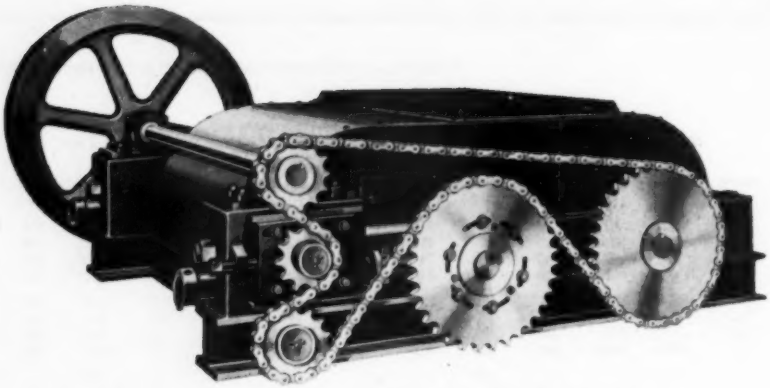
Selection Capacities

In selecting a crusher for a specified duty, the capacities shown in Tables 1 and 2 are for mine-run coal. When the undersize is screened out ahead of the crusher, the capacity is less. Should a crusher be fed with 70 tph of coal from which 60 per cent has been screened out as undersize, the crusher does work on 46 ton of lump. When the feed is 140 tph of coal from which 66 per cent has been screened out as undersize, the crusher has the same job—to crush 46 ton of lump. This explains, for example, why a 30 x 42 in. single roll crusher, Table 2, crushing hard bituminous to 2 in. ring size is listed as having a capacity of 70-140 tph.

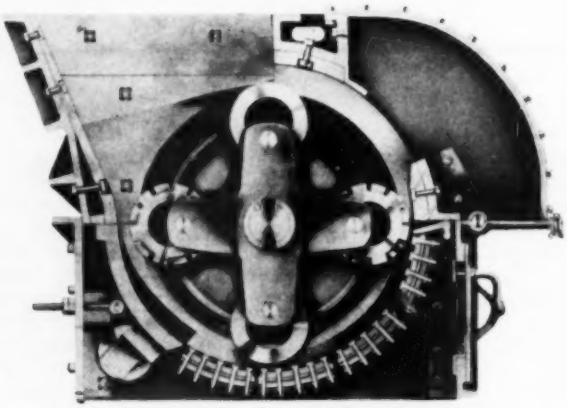
The tables specify the maximum size of lumps the crusher can digest. This may lead to the purchase of a crusher larger and more costly than necessary if the maximum lump should be rare, and can without undue trouble be cracked up with a sledge.

Roll crushers are subjected to sudden severe shock as when a piece of tramp iron or wood enters with the feed. Shear pin protection is usual, but when a crusher or hammermill is not direct-driven, the flexible V-belt drive is better than the rigid chain drive. This reduces the shock on the crusher and motor. The fluid clutch has possibilities.

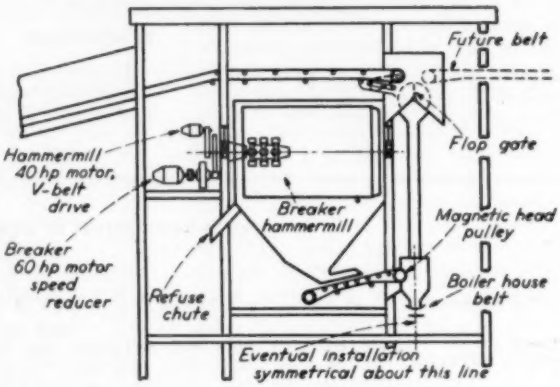
Bradford breakers are not subjected to shock but may overload—more material passing in than the cylinder can clear. This contingency is taken care of by an electric eye. The beam is directed from outside, through the cylinder, operating a time-limit relay connected with the feeder motor cut-out on the opposite side. Should the beam be cut off for an abnormal interval, the feeder stops until the cage has cleared. When desirable, the restart can be automatic.



Double roll crusher is arranged so product size can be made while the unit is operating



Sectional view of a hammermill shows adjustable grinding plate, trap on right, and also the ring type hammers



This breaker hammermill has a capacity of 350 tph of mine-run coal to 1¼-in. ring size with 75 per cent of the product ¾ in. and under

TABLE 3 — BREAKER CAPACITIES

Size of breaker, ft	Approximate ton per hour
6 by 8	30-60
6 by 11	40-70
7 by 8	35-65
7 by 11	45-85
7 by 14	55-100
9 by 11	80-150
9 by 14	100-190
9 by 17	120-230
12 by 11	130-240
12 by 14	160-300
12 by 17	190-360
12 by 19	220-420
12 by 22	250-480

TABLE 4 — CAPACITIES OF HAMMERMILLS, TON PER HOUR

Speed rpm	Approximate hp	Approximate capacities					Size Lump ROM, in.
		1½ in.	1¼ in.	1 in.	¾ in.	½ in.	
600-720	20-25	80	50-65	45-50	35-40	25-30	10
600-720	25-30	90	70-80	60-65	50-55	40-45	12
600-720	30-40	150	130-140	100-120	80-100	60-70	18
600-720	50-60	225	175-200	150-170	130-150	80-100	20
600-720	60-75	300	225-250	200-235	175-200	125-150	24
600-720	75-100	350	300-325	285-325	275-300	175-200	28
600-720	100-125	400	350-375	330-350	300-325	225-250	28
600-720	125-150	450	390-420	360-380	325-340	250-275	28
600-720	150-175	500	425-450	400-425	350-375	275-300	28

Management and Engineer View Dust, Corrosion and ELECTRICAL DISTRIBUTION

Part 2 shows how a chemical plant overcame minimum standard performance in a system less than five years old but installed during equipment shortages. In this plant, corrosion is not as severe as described in Part I and, for reliability, emphasis is placed on alternate power sources and on optimum results in radial aerial cable primary feeders without alternates. Relaying for faults and push-button control also reduce outage time in critical batch processes. Maximum use of old and new equipment permits expansion without interrupting production

HAROLD E. McCONNELL, *Consulting Engineer*

THE PROJECTS described in this and the preceding article reflect the trend of Gulf Coast industrial plants to put their electrical systems on a paying basis with respect to over-all plant production and profits. All improvements were carefully weighed to determine optimum methods capable of furnishing adequate plant power for actual operating requirements.

Operating superintendents were perhaps first to grasp the significance of instantaneous power through push button control. Having become accustomed to these advantages they are no longer satisfied with older methods. The branch circuit breaker gains much of its popularity over switch and fuse combinations because of quick reset possibilities. It is only logical for operating departments to expect the same kind of flexibility in the major distribution system as in local operating control of specific motors and devices. Any purely electrical switching delays or unexpected interruptions of power reduce plant efficiency while operating overhead goes on unabated.

The projects have a number of significant similarities, although many problems and conditions were quite dissimilar. Many similarities occur because of availability or lack of equipment. Engineering looks to the manufacturer, and adapts latest designs and improvements to problems at hand.

For example, aerial cable is a recently developed product for efficient and economical transmission of electrical power, but unless equipped with stainless steel messenger and binder and an acid resistant jacket, it is worthless in the plant with extraordinarily severe corrosion conditions. Likewise, certain standardized methods for switching and control of electrical power exist, but one application may require outdoor construction, another indoor.

Completely reliable power requires alternate cables and power sources, with quick switching and control plus ability to handle almost unlimited fault surges. In over-all principle, methods are pretty much the same, but the application depends upon correctly using the latest and best manufactured items available at the time the need occurs.

A few dissimilarities also occur. The second plant, described in this article, having less serious corrosion problems, uses simple radial feeders with no alternate 2300 v lines available and with no ties between 440 v sources. As further contrasted to the plant described in the first article, the second plant makes little or no attempt to provide short-circuit protection and isolation of radial feeder taps and splices, depending on back-up protection of the feeder breaker itself. Although possibility of providing such additional features was not overlooked in the new design, management decided to defer such considerations until operating experience points out future requirements more clearly.

Both plants adhered to presently accepted good practices for distribution and control of major blocks of power, and now have systems capable of future expansion with ease, economy and far less difficulty in maintaining service during expansion. Neither will be completely free of deterioration problems, or need of good judgment in the operation of their new electrical systems.

Both companies took the earliest possible opportunity to examine their electrical systems after operating experience had confirmed the requirements. A strategic time was picked to correct existing inadequacies by integrating new design so that (a) alternate sources of power became available to take care of old requirements during construction, (b) all expanded power needs are recognized and adequately cared for, and (c) future expansions will be possible with even greater ease and economy.

This is the real essence of modernization of electrical distribution systems for industrial plants. Given the opportunity of proper timing and perspective by plant management, the engineering staff or consultant may

use technical methods best suited to meet specific requirements with greater economy and satisfaction to management.

SECOND CASE HISTORY

This project occurs within one of the many new industrial plants built in this area immediately after the war when many scarcities continued. The plant was well designed, and integrated as self-sufficient within the property lines.

Few specific provisions were originally made for future expansion. For the most part, plant processes operate as closed systems and require installation of additional units for expanded capacity. This eliminated need for building structures larger than required for individual units. The plant operates on a 24 hr basis, with year round rather than seasonal operation.

The original electrical design acknowledged several specific problems due to the Gulf Coast climate, and to possible corrosive effects from chemical pollution by plant processes. Major distribution points were located away from hazardous areas, and when possible, away from areas where escape of chemical products might increase corrosive effects. To date, corrosion of electrical equipment has been fairly well limited to natural causes from atmospheric conditions.

Source Reliability

From the start it was realized that exceptional reliability of the power source would be required. Features not usually found or justified in other plants of relatively low initial electrical demand were incorporated at the primary substation. The processes are heavily dependent upon continuity of electrical power sources. Definite operating sequences are necessary, and usually controlled electrically. They cannot always be correctly restarted at arbitrary times, and whole production batches may be spoiled.

All power is purchased at 69 kv, 3 phase. First consideration in construction of the primary substation was inclusion of separate 69 kv incoming lines from alternate sources provided by the utility company. Each line terminated at steel substation structures, with heavy station type lightning arresters for the incoming line. Separate 69 kv pneumatically operated oil circuit breakers, suitably interlocked, permitted rapid switching (from within the plant) from the normal source to the other in case of failure.

Manual double throw switching could have been installed at much lower cost, using only one oil circuit breaker. However, the extra time to restore power, and the greater hazard to maintenance personnel, made expense of 69 kv breakers preferable.

Substation Location

This power substation had been located on plant property as near as possible to the utility right-of-way to avoid 69 kv line construction in the plant proper, as well as corrosive effects due to chemical pollution. For the most part it is now in excellent condition. However, corrosion of pivot points on the original motor operated disconnects caused motor failures from high initial torque required to free the mechanism. The system was abandoned in favor of group operation of the disconnects from a hand crank on the operating linkage with no excessive difficulties or operating delays up until the present.

Utility company metering had been installed between the common 69 kv bus and a bank of three single phase 1250 kva oil immersed self-cooled* (OISC) transformers, connected 67 kv delta to 2400 v delta. Steel towers and trusses were erected for insulator bus supports and transformer disconnects on both high and low voltage sides.

Transformers had cover bushings for high and low voltage leads. Hook operated disconnects were provided for each bushing so that any transformers could be completely isolated and three phase service resumed with open delta operation. An open 2400 v bus was mounted on the truss immediately above secondary bushings and disconnects, using tubular copper bus bar and heavy duty insulating supports.

Lightning arresters were connected directly to the 2400 v bus, and two shot repeater type arresters were added to the common 69 kv bus in addition to station type arresters previously mentioned. An extensive grounding system was provided.

No serious electrical difficulties have occurred at this substation. Except for proper protective action of the 69 kv circuit breakers upon internal plant faults, no interruption of power has originated from this substation since its construction.

Incoming line power failure has occurred very few times, but the rapid restoration of plant power made possible left management entirely satisfied with its greater initial investment. Insofar as is known, the main breaker has interrupted internal plant faults without operation of utility protective devices.

Through no fault of the author, obsolete terminology was used in Part 1.

Interrupting capacity, about 50 per cent higher than theoretically required for present short-circuit capacity of utility lines, allows for increases.

Original Plant Lines

From this point on, the electrical system (at 2300 v) assumes certain characteristics of a minimum standard system. However, reasonably satisfactory operation has been available to date, although with certain annoying inconveniences to maintenance and engineering.

The main plant process area is roughly centralized about ½ mi from the power substation, requiring a 2300 v transmission line. Two sets of open conductors were strung from 5 kv suspension insulators on pole line structures, terminating at an open tubular copper bus at a wooden structure at the distribution center.

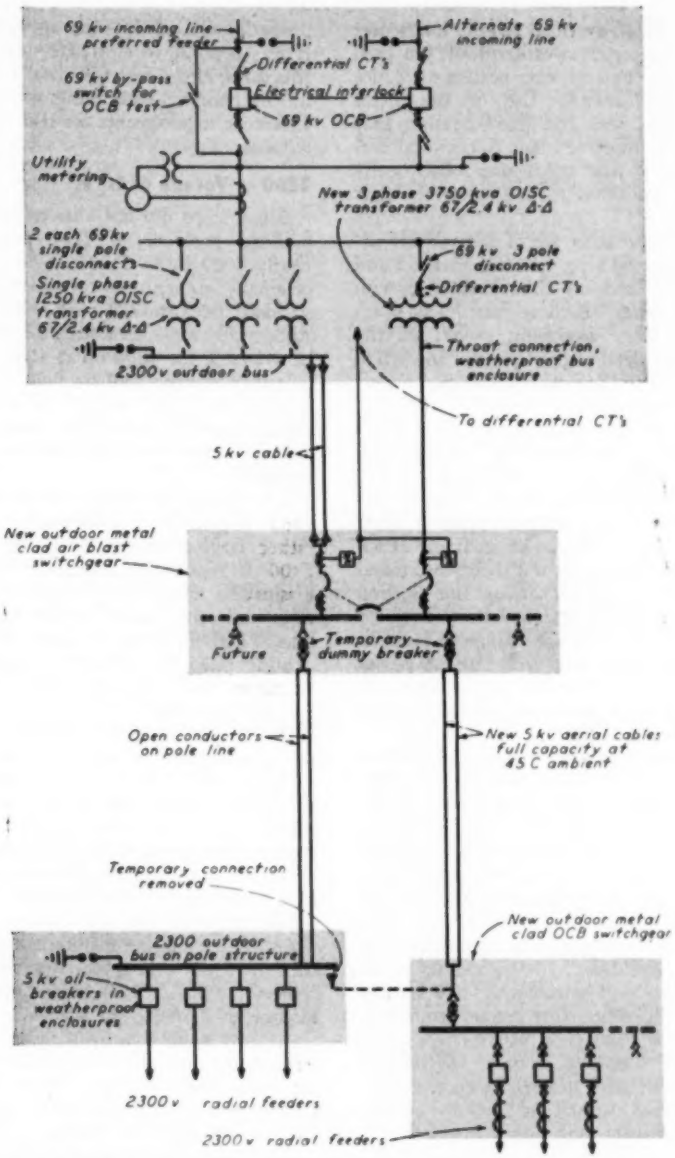
Each set of conductors was arranged horizontally, with no transposition, one set being suspended vertically below the other from cross-arms. Each set was terminated at the power transformer and distribution center buses without benefit of individual disconnects. A continuous, grounded static wire was installed at the pole tops for lightning protection.

The two sets of conductors operating in parallel have a combined size capable of economic transmission of about 2000 hp, the initial demand load. Voltage regulation (before expansion in capacity described later) is a little on the ragged edge and contributes to annoyances previously mentioned, but is within minimum tolerances for distribution work at initial plant demand loads. Voltage unbalance between phases, due to the configuration, has been measured, and is within permissible but somewhat undesirable limits.

No secondary main breaker had been installed, and none was required. Since this line carried all existing plant power and no alternate lines were constructed, the main 69 kv breaker contains all necessary protective and disconnect features. Top quality, pole line materials and construction were used throughout.

No failures have occurred on the line itself and a casual glance from the ground level reveals no serious deterioration. Management has been well satisfied with the performance. But a comparatively recent and detailed inspection by skilled pole line electricians revealed deterioration for which maintenance work could hardly be performed in entirety without a power interruption.

Some hardware was seriously rusted, nearly all was loose. Some insulators


69 kv incoming line preferred feeder
Alternate 69 kv incoming line
Differential CT's
69 kv by-pass switch for OCB test
Electrical interlock
69 kv OCB
Utility metering
New 3 phase 3750 kva OISC transformer 67/2.4 kv Δ-Δ
2 each 69 kv single pole disconnects
69 kv 3 pole disconnect
Single phase 1250 kva OISC transformer 67/2.4 kv Δ-Δ
Differential CT's
Throat connection, weatherproof bus enclosure
2300 v outdoor bus
To differential CT's
5 kv cable
New outdoor metal clad air blast switchgear
Future
Temporary dummy breaker
Open conductors on pole line
New 5 kv aerial cables full capacity at 45 C ambient
Temporary connection removed
New outdoor metal clad OCB switchgear
2300 outdoor bus on pole structure
5 kv oil breakers in weatherproof enclosures
2300 v radial feeders
2300 v radial feeders

One line diagram of the plant distribution circuits shows old circuits on left, and paralled new circuits and equipment on right. New switchgear (across center) was also installed to allow use of either circuit during expansion and in future emergencies. The 2300 v radial feeders, without alternate circuits, supply 440 v load centers and 2300 v motors

were chipped or otherwise damaged. All insulators had lost one or more clamping bolts, with imminent danger of dropping a conductor from a few clamps.

This plant had benefited from the tendency of any system to operate better when new, but now instituted a re-examination at the strategic time before serious failures occurred.

2300 v Distribution Center

At the 2300 v distribution center, individual outdoor type oil circuit breakers had been located on a concrete slab immediately below the 2300 v overhead bus to serve individual 2300 v radial feeders run to principal plant areas. Completely oil immersed in specially built enclosures, these breakers have been satisfactorily resistant to corrosion tendencies at this point. They are of a type not usually considered as distribution breakers, but interrupting capacity is more than adequate here.

The breakers do not have space for overload relays, but have current transformers and instantaneous relays. For open overhead lines terminating in suitable load protective devices, overload protection is often omitted, or can always be set for overload conditions much higher than permissible for insulated cables.

An attempt at some measure of overload protection had been made by setting the instantaneous ratio quite low. Starting currents of large motors consistently tripped the instantaneous relays under near loaded conditions and the coils had to be rewound for a normal ratio.

Most of the lines, although primarily open construction, contain one or more vital links of underground insulated cable, and these lines were consequently left without overload protection of any kind. Ample installed capacity kept this from being a serious concern until expansion plans called for load increases on existing lines.

Original 440 v Circuits

The 440 v substations (before expansion) consisted of three single phase oil immersed transformers on outdoor slabs, with both primary and secondary enclosed terminal chambers, and no live parts exposed to direct corrosive influences. Branch 440 v circuit breakers were usually installed on outdoor racks in cast iron or oil immersed enclosures and connected in conduit runs to motor starter racks of similar construction. A great many 440 v starters are oil immersed.

In general, the 440 v system ranks as a first class installation, rather than minimum standard, with little to be desired as compared to other installations of a similar nature. Except as influenced by voltage regulation of the 2300 v circuits, performance has been excellent.

High Voltage Motor Circuits

Motors of 100 hp and larger are operated from 2300 v lines and account for 30 to 40 per cent of total connected motor load, an unusually high percentage. Starters have individual fuse cutout disconnects, are generally well installed, and satisfactory in operation. A few indoor type starters, installed in electrical equipment rooms thought to be dry and free from corrosion, showed evidences of deterioration to parts of the control system. Strip heaters were added as the cheapest and easiest solution, since experience in this climate shows this is nearly always a desirable procedure to avoid condensation due to the high humidity.

Main lighting transformers are three phase, four wire units, with well bal-

anced loads. As a whole, the plant load is remarkably well balanced.

Distribution Feeders

2300 v radial branch feeders are of the same general construction as that used on the main line, with similar performance history in most cases. One of the principal difficulties, which will get worse before it can ultimately be corrected, is that of voltage regulation in the system.

One of the heaviest loaded important lines is also the longest branch line. In order to overcome the cumulative voltage drops in the transmission line system and get minimum permissible operating voltage for large 2300 v motors, power transformer taps were set at a fairly high voltage, making terminal voltage for the shortest lines higher than desired.

Lighting transformers were unfortunately not equipped with taps for this high voltage range. Consequently higher voltage lamps have to be stocked for that part of the plant, with a very high lamp replacement rate occurring. 2300 v synchronous motors in the plant permit an average power factor well above 90 per cent, but have been unable to sufficiently improve the voltage regulation.

Expansion Plans

Expansion plans called for a sudden and major increase in demand load, but within the limits of the installed 3750 kva capacity of the power transformers. This was to be followed reasonably soon thereafter by further increases well above existing capacity.

First problem in the expansion was to get the immediate job done as rapidly as possible, with little or no interruption of existing plant services, and yet have an installation easily adapted to future increases. Consequently, all parts of the new system would be integrated as a single, well designed system rather than to result in a makeshift combination.

New 2300 v Feeders

The first increase called for new 2300 v branch feeder lines from the distribution center, and for increased loading of certain existing feeders. This required some shifting of load on these lines. The ultimate increase unquestionably called for new power transformer capacity, and new transmission lines to the distribution center near the production area.

It was decided to use modern, metal clad, outdoor switchgear as the focal point of all new branch 2300 v feeders, with oil circuit breakers of adequate interrupting capacity and with both instantaneous and inverse time delay overload relays. Enclosures are completely weatherproof, but each section contains strip heaters to reduce condensation. Use of oil circuit breakers was continued because they will be more resistant to chemical corrosion if new production subsequently adds pollution to this relatively clear area.

The breakers are of the vertical lift withdrawal type, for easy removal and repair, and are interchangeable with each other. Each is electrically operated from a closing switch on the safety dead front panel, on which glassed in, dust-tight relays and meters are mounted.

With the exception of the utility metering, no metering of any kind previously existed within the plant. Considerable maintenance trouble was necessary even to get voltmeter readings from the 2300 v lines. Each feeder now has a watt-hour meter and ammeter. The incoming line section has ground detection voltmeters, from which the voltage balance between phases can be read with ease. A power factor meter will now enable better adjustment of power factor correction by synchronous motors.

Additional 440 v motor capacity is added by several new three phase 2400/480 v outdoor type unit substations. They have oil immersed primary terminal chambers and disconnect, a three phase OISC transformer with standard taps, throat connected 440 v draw-out circuit breakers, and strip heaters for each switchgear section. Additional 2300 v motors are to be controlled by across-the-line starters with individual fuse cutout protection. They are the same general types previously found to be quite satisfactory, but with strip heaters in each starter. One such substation replaces an unsatisfactorily long 440 v line.

Aerial Cables

Conditions in the plant favor overhead construction, rather than the more expensive underground construction for long 2300 v feeder lines. Self supporting, pre-assembled aerial cables were selected. With complete protection by the new switchgear, the far better kva-distance constants inherent to three conductor cables could be used. However, thermal radiation properties of the insulated conductors are not as high as for open weatherproof conductor, and they must be carefully protected from overloads which might damage the insulation.

The aerial cable does not need lightning arresters if the messenger is well grounded, eliminates unsightly pole line construction, and is generally resistant to moisture and corrosion if properly selected for the application. It was possible to eliminate new pole structures altogether for most of one run by hanging to existing structures. Clearance requirements are also greatly reduced.

2300 v Versus 4160 v

These steps did not answer the immediate problem of transmitting nearly 4000 hp at 2300 v over a line originally designed for minimum standard performance with 2000 hp. About the same performance would be available for 4000 hp at 4160 v. It is rather obvious that original design contemplated this change in case of greatly increased demand, although the only provision was 5 kv hardware and fittings.

The change to 4160 v would be a good engineering approach. The rather large kva-distance product at 2300 v represents increased copper dissipation losses, and difficult if not disastrous problems of voltage regulation at higher current densities on the existing line. At this point, materials shortages and urgently needed production interfered.

A few of the 2300 v meters may be reconnected for 4160 v, but the majority would have to be rewound. In addition, most existing starters are not designed for 4160 v and would require either replacement or extensive changes. Both represent interruption of production, as well as very high initial cost.

Other means permit reconversion back to 2300 v at motor distribution centers without change to either motors or starters, probably at lower direct cost and certainly with less interruption. But such equipment was listed for long delivery. These conditions precluded immediately changing transmission line voltage.

The 2300 v distribution voltage for the indefinite future demanded that the new main substation transformer also operate at 2300 v in an integrated electrical system. A three phase transformer of 3750 kva self-cooled capacity, with 25 per cent increase with future forced air cooling was selected. It may be reconnected for 4160 v.

2300 v Transmission Line

The main power substation will represent 7500 kva capacity immediately, of which an ultimate need of about 6000 kva can be accurately forecast at the present distribution center. Of this, perhaps 2250 kva can be transmitted with fair efficiency over the present line and the immediate problem was a method of transmitting an additional 3750 kva.

Two aerial cables in parallel, of ap-

propriate copper size, would maintain a favorable ratio of dissipation losses to initial cost, per Kelvin's law, and reduce total voltage drop to about one third that for open construction. The cables have uniform spacing and arrangement, and will cause no voltage unbalance. The grounded messenger is very effective lightning protection. Cost of the cables is considerably greater, but is somewhat offset by the greatly reduced cost of pole structures, and extra cost of bare copper if a satisfactory voltage regulation were to be obtained from an open line.

However, avoiding excessive copper temperatures required overload and short-circuit protection. This was provided by another set of metal clad switchgear at the power substation throat connected to the new transformer in typical unitized style.

With the installation of the new aerial cable, less copper actually did a better job with very good operating economy. Therefore, no major changes will be made to the existing open line for the indefinite future, and an attempt will be made to coax it into transmitting the required immediate increase in power before arrival of the other major equipment.

With certain redistribution of load on existing branch feeders, and better utilization of the synchronous motors, acceptable operation appears barely possible, but at greatly increased copper dissipation and maintenance cost. Therefore, new switchgear at the distribution center was to be temporarily connected to the old line, and reconnected to aerial cable feeders upon their arrival. Then it would act as the sole distribution center for 3750 kva of new transformer capacity, and old gear would remain undisturbed for that portion of the old transformer capacity economically transmitted on the old line.

Addition of the new transformer and parallel transmission line allowed interesting possibilities for making the plant distribution more compatible with the extra features built into the 69 kv side of the substation. It also added the problem of effective protection of two, three phase transformers on the common 69 kv bus, rather than one as before.

Protective Features

To prevent serious plant overloads from damaging the transformers (as well as protecting aerial cables from overload) secondary main circuit breakers, with inverse time delay relays and instantaneous relays, were provided in the new switchgear assembly for both old and new transformers. Main feeders are connected at feeder sections of the gear through dummy breakers.

Thus major internal plant faults which may escape coordination by the gear at the distribution center may be coordinated and cleared by the proper secondary main breaker. Otherwise, the main 69 kv breaker would interrupt all plant power, or much more expensive, additional 69 kv breakers would be necessary.

Differential relays were added, however, for complete protection of transformers from a major fault in transformer windings or secondary connections. Such a fault would temporarily interrupt all plant power, by tripping the main 69 kv breaker, but the instrumentation on the differential relays permits quick recognition and isolation of the faulted bank and restoration of power to the remaining bank.

Prospects of transformer failure are remote. The positive protection of differential relaying at expense of a brief shut-down can hardly justify the much greater cost of separate primary circuit breakers, which are also critical delivery items.

Open type fuse cutouts would not necessarily give the same measure of protection as differential relaying and would cost approximately the same. Although used by the utility company to some extent, they are not generally favored for higher voltages in industrial plants because of corrosion and extra hazards to personnel.

Tie Breaker Included

Having the two secondary main breakers so close makes the inclusion of a tie breaker inevitable for extra flexibility. Its use extends the principles of alternate power sources originally built into the 69 kv side to the secondary side, and allows energizing each main feeder from either transformer. During low power demand, one transformer may be completely removed from service for necessary maintenance and repairs. In emergencies, some curtailment is necessary if only one power transformer is in service, but all vitally necessary lines can be energized.

Future Expansion

In normal operation the tie breaker will be interlocked in off position. But company engineers and management realize that plant expansion can continue faster than expected. Switchgear specifications provided an interrupting capacity more than adequate to permit parallel operation of two transformer banks. If expansion includes need for a third transformer, parallel operation of two banks, slightly overloaded, could serve entire plant demand for short periods.

With future forced air cooling, total installed capacity will reach 8400 kva with adequate present transmission line capacity for transmitting 6000 kva to the distribution center. About 900 kva spare capacity remains in the new bank, and about 1500 kva in the old. Since future load locations cannot be forecast, the only provision is for extending the power substation switchgear in either direction. Addition of one or more feeder breakers will permit transmission of the remaining power to any location, without additional investment at present. For new loads near the old distribution center, aerial cable can be attached to the structure for the main aerial cable feeders.

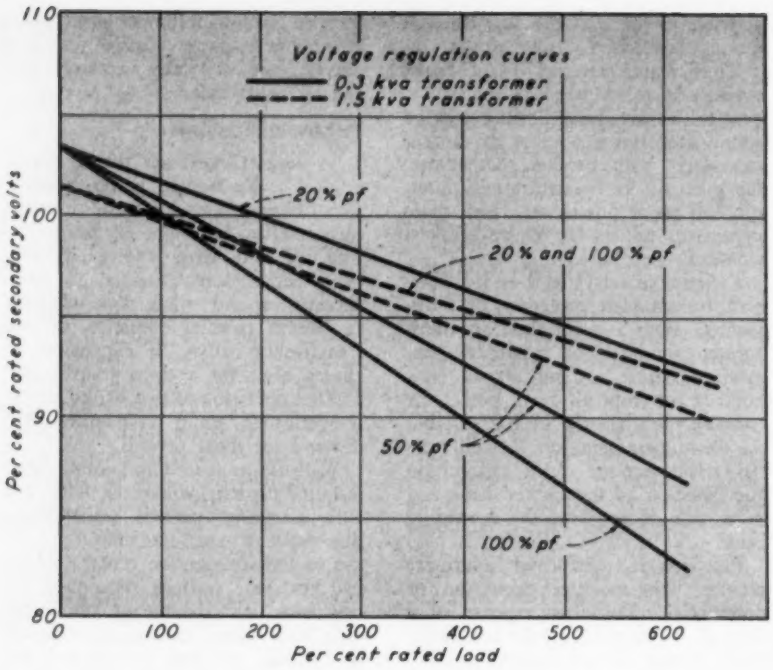
The diagram shows essential features as described. Many additional problems have not been discussed, but the system represents a good and workable solution which could be installed in time to meet production demands. If this construction program had developed at a time when materials were not scarce, it is entirely possible that different methods might have been used. But the system is well adapted to meet all immediate plant problems satisfactorily. Also, it is sufficiently flexible for extension in any of several directions with ease and economy.

This Article Was Selected Because—

It includes many phases of management, economics and engineering that cannot and should not ordinarily be included in discussions on basic features and recommendations of distribution systems. Furthermore, most of the problems treated in the article are occasionally encountered throughout a plant, and a few are found in isolated areas in most plants.

It is recognized that, since the distribution system is a small percentage of plant investment but such an important item in the operation, compromises should be made grudgingly, if at all. But experience in industrial plants shows that there are many unusual conditions which must be met with ingenuity, and without information on other installations which would enable prediction of equipment life and operation.

INDUSTRY AND POWER will welcome correspondence expressing your views and experience as a guide for future article selection.



IMPORTANT

- Transformer ratings
- Connected loads
- Load power factor
- Intermittent loading
- Load duration
- Temperature rise
- Weighting factors

Fig. 1—Power factor affects voltage regulation of all transformers but is particularly important on controls and other small units where peak loads may greatly exceed ratings and be highly inductive, as with relays and motors

IF A CONTROL ENGINEER were to be thorough in his analyses of control transformer applications he would at one time or another ascertain the answer to such questions as these:

1. Should the transformer conform to NEMA standards?

2. Should it be Underwriters' Laboratories approved?

3. Must it meet any other standards or specifications?

4. Which transformer most satisfactorily combines the non-electrical features of suitable terminal arrangements, desirable dimensions, good appearance, and convenient mounting provisions?

5. What type of insulation is required by ambient temperatures or other conditions?

6. Should the transformer have built-in overcurrent protection for excess temperature?

7. What should be the volt-ampere rating?

Fortunately, the answers to all but the last question can be obtained on the basis of specification requirements and good judgment. The determination of adequate transformer capacity also requires good judgment, especially where great economy is necessary, but the judgment can be based upon engineering estimates or calculations when application and duty cycle of the transformer are known.

Transformer Capacity

Calculations for selecting transformer capacity are of two general types; the first is to determine if the transformer is large enough to deliver adequate voltage to a load; the second is to investigate what the load will do to the transformer.

One of the simple rule-of-thumb methods commonly used is: Take 25 per cent of the maximum instantaneous current, and then ascertain the maximum steady load on the transformer. The larger of these two values determines the transformer rating. This method considers both ability of the transformer to deliver the required voltage and heating effect of the current.

However, where several starters, relays, solenoids or other devices are energized at various times during the operating cycle, and their requirements are appreciable in relation to the capacity of the control transformer, it is sometimes desirable to make a more accurate estimate of transformer size than can be done by the simpler methods such as the one noted above.

Rating for Load Voltage

It is possible to calculate voltage delivered by a transformer if one has data on the internal impedance characteristics of the transformer and also knows the magnitude and phase angle of the current required by the load. However, it is much more convenient, and usually accurate enough, to use voltage regulation curves for estimating output voltage. These curves can be supplied by the transformer manufacturers, or may otherwise be readily obtained by the control engineer. Typical voltage regulation curves for several power factors are shown in Fig. 1.

For the overload range in which we are interested, voltage regulation curves can be regarded as straight lines. This means that if the voltage at full load rating drops 3 per cent below the no load voltage, it will drop 6 per cent for twice rated load at the same power factor.

Effect of Power Factor

Power factor of the load current affects output voltage because the voltage drop in the transformer is due to its internal resistance and reactance. These subtract vectorially from the induced voltage in the transformer to give the output voltage. The phase relation of these vectors is influenced by the phase relation or power factor of the load current.

A transformer has its poorest regulation, that is, the least output voltage, when the resistance and inductance of the load are in the same ratio as the internal resistance and leakage inductance of the transformer. The im-

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From a paper presented at the 1952 Annual Machine Tool Electrification Forum sponsored by Westinghouse Electric Corp.

CHARACTERISTICS OF CONTROL TRANSFORMERS

You may seldom have enough control transformer applications fitting a given set of conditions to justify complete engineering. But this clear analysis of fundamentals and short cuts possible will help even in making quick estimates or in analyzing malfunctioning of controls, as for example, where extra loads have been added. The principles also apply to small transformers used for other than control purposes

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pedance drop then subtracts directly from the induced voltages. Load power factors below or above this value result in better voltage regulation for the transformer.

Variations in Load Voltage

Examination of the curves in Fig. 1 shows that 90 per cent of full load voltage will be delivered to a 50 per cent power factor load when the 0.3 kva transformer supplies 500 per cent rated load or when the 1.5 kva transformer supplies 650 per cent rated load. These curves show also that if the steady load on the transformer is 50 per cent of the rating, the voltage will be about 105 per cent normal for the 0.3 kva unit and 1.02 per cent normal for the 1.5 kva transformer. The larger the transformer, the better its regulation.

In deciding how much voltage drop may be allowed in the transformer, it is necessary to consider the normal supply voltage variations which may be expected and also the minimum voltage at which the control devices will operate. Supply system voltages usually are regulated to within plus or minus 10 per cent of nominal, but occasionally additional variations occur as the result of load and distribution system conditions in a plant.

The latter variations are not normally considered, but when they are discovered as the result of malfunctioning of a new machine tool it is sometimes embarrassing to the equipment manufacturer.

For Combination Loads

Where several load demands are applied in various combinations, the transformer voltage output may be determined for any combination by finding the magnitude of the combined load. Ordinarily, it is voltage drop due to the largest instantaneous load that must be considered. This maximum load may be a combination of steady and inrush currents having different power factors.

However, it is usually satisfactory and always on the conservative side to add the volt-ampere values arithmetically rather than vectorially, using the power factor of the load component which gives the lowest output voltage. If closer design is required, use the actual power factor of the maximum instantaneous volt-ampere load.

Estimation of output voltage is seen to be relatively easy once inrush and steady or sealed currents of the load devices are known. For example, a steady load consisting of 0.2 kva at 50 per cent power factor plus an inrush load of 0.75 kva at 20 per cent power factor would represent an arithmetic total of 0.95 kva., or 317 per cent load on the 0.3 kva transformer in Fig. 1. Assuming 50 per cent power factor for the combined load,

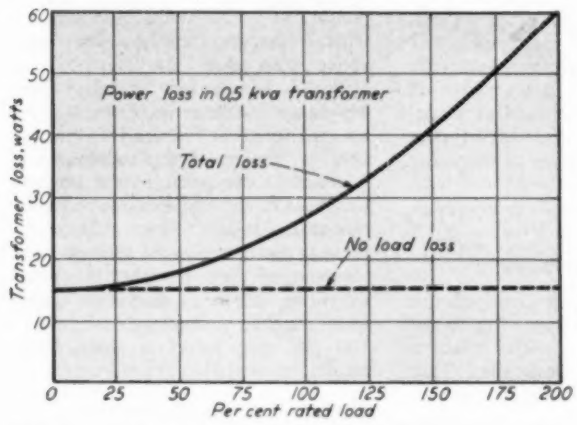

Fig. 2—Power losses, which determine temperature rise, are typical, with a no load component plus losses which increase as square of load current. No load temperature rise limits magnitude and duration of the applied loads

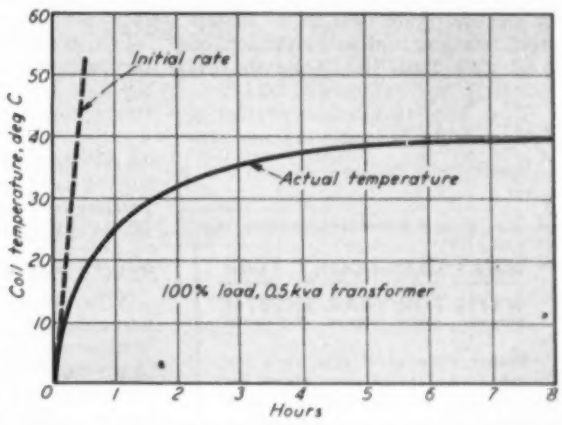

Fig. 3—The theoretical temperature rise for steady load gradually reaches a constant value. However, for short overloads, the initial rate, dotted line, is important. The curve is modified by original temperature conditions

secondary voltage is found to be 95 per cent of rated voltage on the 50 per cent power factor load curve. Actually, the combined load, because of different power factors, is only 0.93 kva at 27 per cent power factor, which results in about 97 per cent secondary voltage.

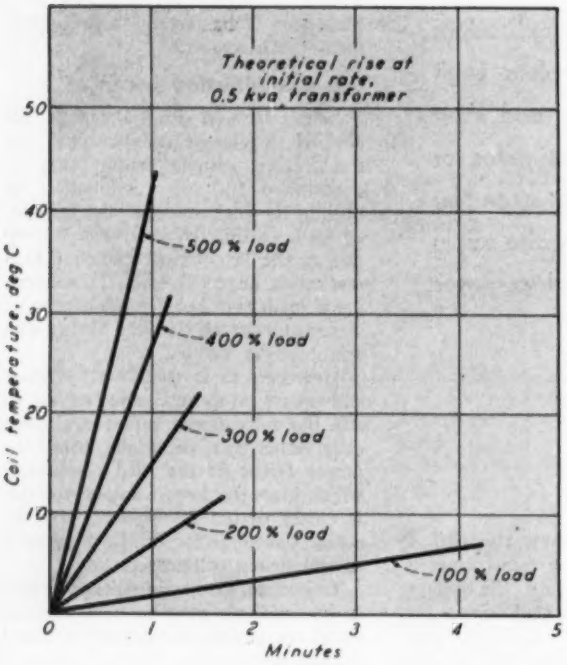

Fig. 4—The initial winding temperature rise for a 0.5 kva transformer under various load conditions indicates the effect of the heavy momentary overloads often encountered with control transformers. Losses retained in windings during the first few seconds are important in cyclic conditions of transformer loading

Transformer Heating

Now for calculations to determine what the load will do to the transformer. Fig. 2 shows the relation between load on a typical 0.5 kva transformer and power loss in it. In this unit, core loss is about 55 per cent of total full load loss. Only the I^2R (copper) loss varies with load.

It is easy to estimate whether a fairly continuous load will cause excessive heating. But how can heating effect be estimated for a load which varies cyclically over a range of values, especially when solenoid or starter coil inrushes occur frequently?

Fortunately, transformers have appreciable thermal mass or inertia. Rate at which temperature of a typical transformer actually increases when full load is suddenly applied is shown graphically in Fig. 3. During the first half-hour, the temperature rises rapidly to nearly 50 per cent of its ultimate value. This rise is due to the combined core loss and copper loss.

Even at no load the transformer will become warm and shorten somewhat the time required for it to reach full temperature when the load is subsequently applied. Several transformers of different makes serve as the basis for the statement that the no load temperature rise in the winding usually is in the range of 12 to 19 C.

Short, Heavy Overloads

What would happen if all of the heat from the I^2R (copper) loss in the transformer windings were retained in the copper for a short time? This practically happens during the first 10 sec that a load is applied. The initial temperature rise of the winding for one to five times rated load would be as shown by the curves of Fig. 4. These curves give an idea of how rapidly a heavy load will increase the temperature of the windings.

In the line of transformers for which Fig. 3 and 4 apply, a 0.15 kva transformer winding heats about 50 per cent more rapidly, and the 1.5 kva transformer about 45 per cent less rapidly than the 0.5 kva transformer in the first few seconds immediately after a load is applied.

A load several times rated value should not be applied to an already warmed-up transformer for more than a few seconds at a time.

The lower curve, Fig. 5, shows theoretical time required for a given overload to raise copper temperature by four degrees centigrade assuming no heat flow from the copper. An eight degree rise would occur in slightly more than twice the time indicated for a four degree rise.

The weighting factor in Fig. 5 can be used to determine average heating in a transformer when the overloads are of short duration. This curve is derived on the basis that the heating effect of the load is proportional to the square of the current. For example, a 200 per cent load will cause four times the temperature rise produced by 100 per cent load.

Safety Factor

A small safety factor which increases with heating effect of the load has been arbitrarily introduced. Its purpose is to compensate to some extent for the momentary excess temperatures which may result from inrush currents. This arbitrary factor increases from 1.004 at rated load to 1.1 at five times rated load, and 1.4 at ten times rated load.

The formula for the weighting factor is:

$$\left(\frac{\text{load}}{\text{rated load}}\right)^2 \times \left[1 + 0.004\left(\frac{\text{load}}{\text{rated load}}\right)^2\right]$$

This expression applies for loads above rated value.

For loads below rated value, weighting factor varies from 0.33 at no load to 1.0 at full load, in proportion to square of the current. The factor 0.33 corresponds to a no load temperature rise equal to one-third the rise at rated load. Since many transformers have somewhat less no load temperature rise, the heating effect weighting factors as shown are slightly larger than necessary for less than 100 per cent load on these transformers.

Factor for Cyclic Heating

To use the weighting factor curve, which can be applied to standard makes in the normal range of control transformer sizes, it is necessary to

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know only the various magnitudes of the load and time duration at each magnitude. The time average of the load weighting factors can then be computed as shown in the example in the table, where the various loads occur in the sequence in which they are listed. The weighting factors are determined from Fig. 5 for any ratio of load to rating from zero up to ten.

The average weighting factor will indicate approximately the ratio of transformer average temperature rise for short overloads to its full load steady state temperature rise. In this example, the average factor of 1.04 indicates an average rise of 57.2 C in a 55 C transformer.

SAMPLE CALCULATION—TIME AVERAGE OF WEIGHTING FACTORS

Event	Per cent load	Load duration, sec Column a	Weighting factor, Fig. 5 Column b	Product of Columns a and b
Starter 1 closes	200	0.02	4.0	0.1
	30	5.0	0.4	2.0
Solenoid & relay on	400	0.5	17.0	8.5
	150	14.0	2.1	29.4
Solenoid off	70	5.0	0.65	3.2
Starter 2 on, 1 off	500	0.03	28.0	0.8
Relay off	90	100.0	0.86	86.0
Starter 2 off	0	0.0		0.0
Total		124.55		130.0

$$\text{Average weighting factor} = \frac{124.55}{130} = 1.04$$

Alternate Method

An approximate alternative to the method of using weighting factors is the elementary but more laborious method of plotting load (as ratio of load to rated load) during each interval of the cycle, using time for the abscissae. The ordinates of this load curve are then squared and a new curve drawn.

The *average ordinate* of the squared curve is approximately the average weighting factor for heating effect. However, this elementary method does not take into account the no load temperature rise, nor the small factor of safety which is included in the curve of Fig. 5 for overloads.

Where inrush currents exceed the transformer rating, it is evident that they do contribute to the average heating if they occur frequently enough or last an appreciable part of 1 sec.

For control transformers where starter coil inrush currents are of normal duration and frequency of occurrence, the heating effect is negligible. The inrush current for the coil of the ordinary motor starter lasts much less than 0.1 sec.

Time Limit for Overloads

An additional application for the curves in Fig. 5 is determination of the permissible on time for intermittent loads. The reciprocal of the weighting factor is the fraction of the time that the load may be applied without producing excess average temperature rise.

This fraction must be further reduced as the length of the "ON" periods is increased over the periods which will permit a 4 C rise. A 500 per cent load, for example, may be applied for 1/27.5 part of the time. The copper temperature rise will be 4 C in the first 6 sec. If 6 sec is the "ON" period, the instantaneous peak temperature will just about reach the normal full load temperature in steady cyclic operation.

Experience will enable one to decide when a simple rule-of-thumb method of estimating control transformer size needs to be supplemented by a more detailed method such as has been described.

Conclusions

The weighting factor curve can be used with various types and sizes of control transformers either to determine the heating effect of complex periodic loads or to determine what fraction of the time an intermittent load might safely be supplied.

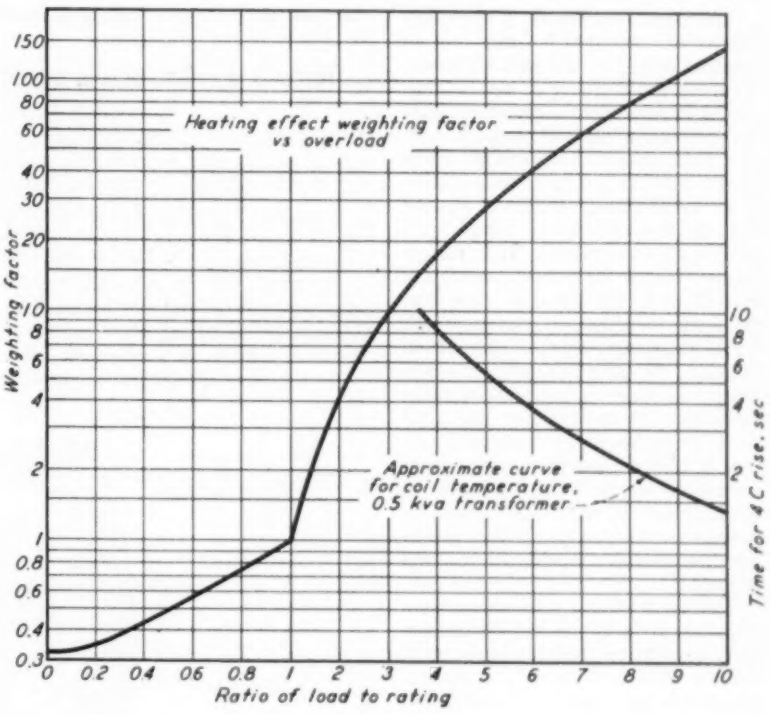


Fig. 5—Curve at lower right shows approximate time required for various loads to produce a 4 C rise in 0.5 kva transformer. Time for higher rises is almost in proportion. The upper curve gives weighting factor by which a load should be multiplied to find heating effect, and includes safety factor for this size. Weighting factor is number of times a temperature rise at rated loads is increased

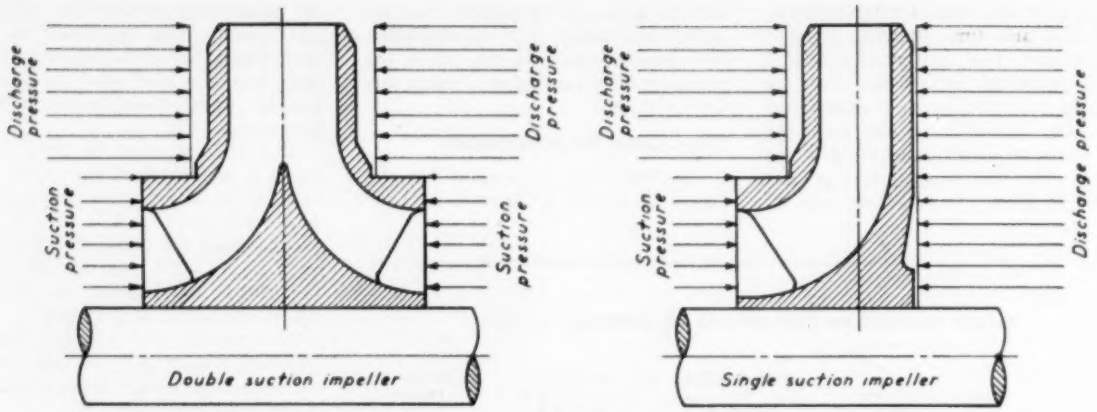


Fig. 1—Comparison of double and single suction impellers with reference to origin of axial thrust

STRUCTURAL DETAILS AND AXIAL THRUST of Centrifugal Pumps

Importance of axial thrust in centrifugal pumps and steps to reduce it to the minimum are brought out by the authors. Each type of pump is reviewed, and methods to reduce thrust are detailed

IGOR J. KARASSIK and ROY CARTER, *Worthington Corporation*

PRESSURES generated by a centrifugal pump exert forces on both the stationary and rotating pump parts. By virtue of design some forces are balanced while others may be unbalanced, and means may have to be employed to counterbalance them.

Axial hydraulic thrust is the summation of unbalanced forces on an impeller acting in the axial direction. However, axial thrust in single stage pumps is no longer a matter of great concern except for certain high pressure applications and in large units.

An ordinary single suction radial-flow impeller, with the shaft passing through the impeller eye, Fig. 1, is subject to axial thrust. This is true because more back wall surface is exposed to the discharge pressure than the front wall, and a portion of the front wall is exposed to the suction pressure. When pressure in the discharge chamber is uniform over the entire area of the impeller, the axial force acting towards the impeller suction would be equivalent to the product of the net pressure generated by the impeller and of the unbalanced annular area. In contrast, a double suction impeller is theoretically in axial balance.

This axial balance of double suction impellers is based on the assumption that liquid enters the impeller in equal volume from both sides. As the impeller inlet openings are also supposed to be equal, pressure on one side of the impeller is equal and opposite to that on the other side. Practically, a double suction impeller may still develop an unbalanced axial thrust for a variety of reasons. Liquid whirling around the outside surface of the impeller shroud does not necessarily have the same characteristics of flow on both sides. This is especially true if the impellers should not be centrally located in the casing, thus setting up pressure differences between the sides.

In the event the suction passages do not afford an absolutely symmetrical flow to the two sides of the impeller, there is the possibility that these two sides will perform unequal work. Such a condition affects both pump efficiency and theoretical balance of the axial hydraulic thrust. The same inequality may be imposed by conditions external to the pump, such as the location of an elbow too close to the suction nozzle. Finally, there may be

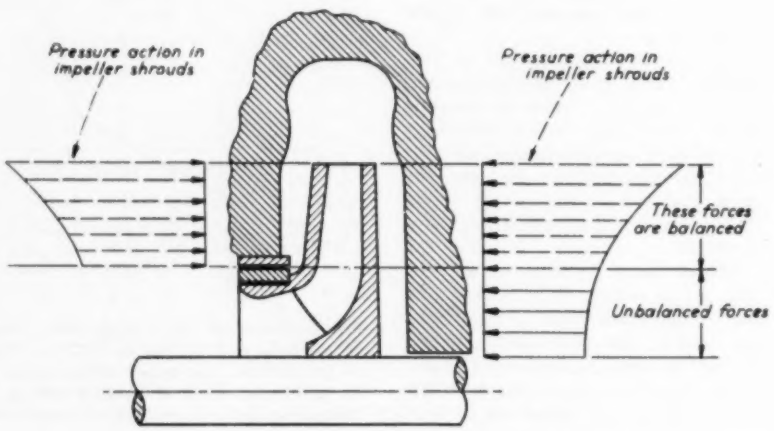

Pressure action in impeller shrouds
Pressure action in impeller shrouds
These forces are balanced
Unbalanced forces

Fig. 2—Pressure distribution on front and back of single suction impeller

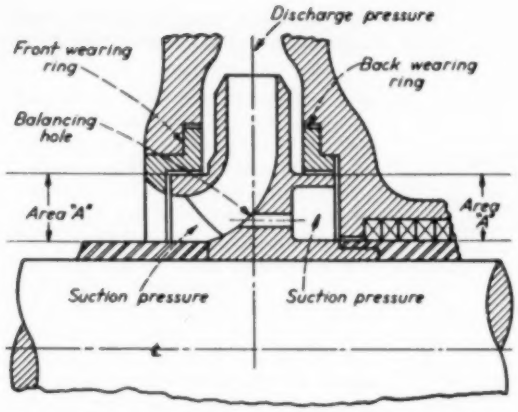


Fig. 3—Thrust of single suction impeller can be balanced by means of wearing rings and balancing holes

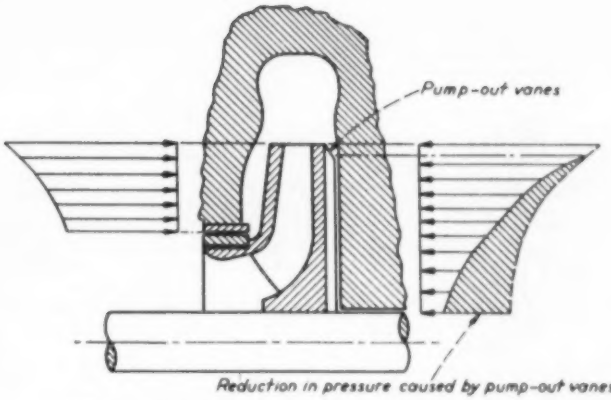


Fig. 4 — Thrust of single suction impeller is balanced by installation of pump-out vanes located on the back shroud

an unequal amount of leakage taking place past the two wearing rings. All of these factors may unite to create a definite axial unbalance, which must still be compensated, and, therefore, all centrifugal pumps are provided with thrust bearings.

Actually, the pressure acting on the two walls of a single suction impeller is not uniform over the entire area exposed to the discharge pressure. This lack of uniformity arises from the fact that liquid between the impeller shrouds and casing walls is in rotation. Thus the pressure acting at the impeller periphery is appreciably higher than at the impeller hub. Therefore, the axial thrust acting towards the impeller suction is somewhat less than the net pressure times the unbalanced area. As an approximation, this thrust may range from 70 to 80 per cent of the value that would be based on the assumption of a uniform pressure distribution.

In order to eliminate axial thrust of a single suction impeller, wearing rings should be provided on both sides with identical diameters so as to equalize the thrust areas, Fig. 3. Pressure on both sides of the impeller is maintained substantially equal to the suction pressure by providing so-called balancing holes or ports. Leakage past the back wearing ring is returned into the suction area through these balancing holes. In certain cases—especially when large single stage single suction pumps are involved—balancing holes are considered disadvantageous because the leakage into the impeller suction is in a direction opposite to the main flow. This creates undesirable disturbances. Balancing holes are then replaced with a piped connection to the pump suction.

Another method to eliminate or reduce axial thrust of single suction units is to provide pump out vanes on the back shroud of the impeller. These vanes reduce the pressure acting on the back shroud of the impeller, Fig. 4. However, this construction is mostly limited to pumps handling gritty liquids, where it serves the primary purpose of keeping the clearance between the impeller back shroud and casing free of foreign matter.

Axial forces acting on an overhung type impeller with a single stuffing box, Fig. 5, are definitely affected by suction pressure. In addition to the unbalanced force, Fig. 2, there is an axial force equivalent to the product of the shaft area through the stuffing box and the difference between the suction and atmospheric pressure. This force, therefore, may act either towards the impeller suction when the suction pressure is less than atmospheric, or in the opposite direction when higher than atmospheric.

Magnitude of this force when the pump operates on a suction lift is very low. For instance, when the shaft diameter through the stuffing box is 2 in. (area—3.14 sq in.) and the suction lift is equivalent to 20 ft of water (absolute pressure—8.66 psi) the axial force caused by the overhung impeller, acting towards the suction, will be only 27 lb. On the other hand, when the suction pressure is 100 psig, the force will act in the opposite direction and will be 314 lb. Obviously, since the same pump may be applied to a variety of conditions of service over a wide range of suction pressures, the thrust bearing of single suction overhung impellers must be generally arranged to take thrust in either direction. It must, therefore, be selected with a thrust capacity sufficient to counteract forces set up under the maximum suction conditions, which have been established as the maximum limit for the particular pump in question.

However, certain special applications lead to the creation of extremely

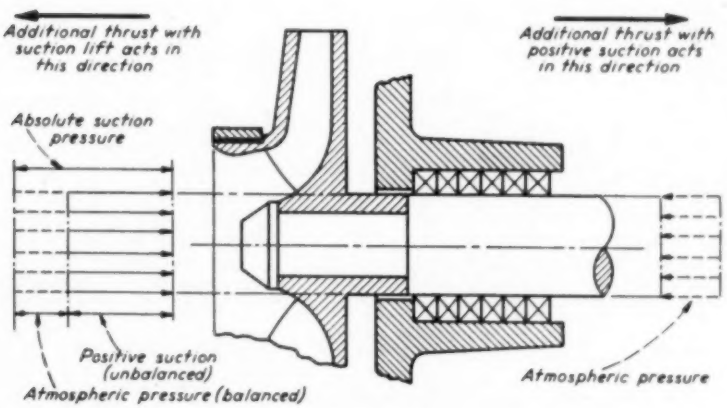

Additional thrust with suction lift acts in this direction
Additional thrust with positive suction acts in this direction
Absolute suction pressure
Positive suction (unbalanced)
Atmospheric pressure (balanced)
Atmospheric pressure

Fig. 5—Single suction overhung impeller pump, shown, has single stuffing box

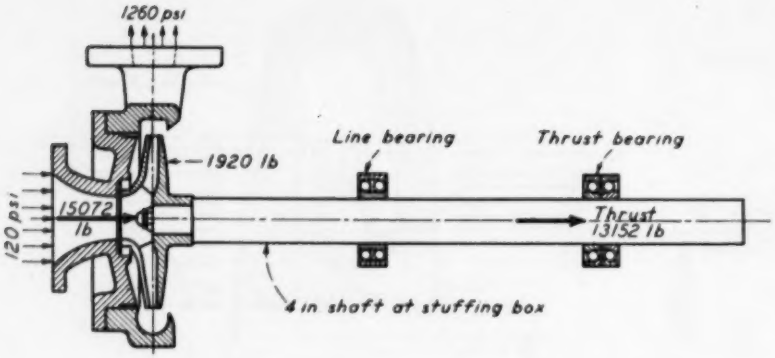


Fig. 6—Typical axial thrust in single suction impeller boiler circulation pump

high axial thrust, for example, boiler circulating pumps. In order to reduce stuffing box maintenance these pumps are generally constructed in the single suction, single stage overhung impeller type. Force acting on the shaft towards the right, Fig. 6, is the product of 1200 psi (difference between suction and atmospheric pressure) and of 12.56 sq in. (unbalanced area of a 4 in. shaft) or 15,072 lb.

As the impeller is not fitted with a back wearing ring, to take advantage of the axial thrust on the impeller itself, this thrust acts towards the *left* of the impeller. Providing the impeller with a back wearing ring would reduce the pressure on the stuffing box by the net pressure developed by the pump. But, since this pressure is only 60 psi, the back wearing ring would reduce the stuffing box pressure by a mere 5 per cent on a 1200 psi boiler circulating pump, certainly a negligible attainment.. On the other hand, the partial balance of the axial thrust obtained through the elimination of the back wearing ring is very useful. Assuming the unbalanced area of the single suction impeller is 40 sq in., net pressure is 60 psi, and average pressure acting on the back shroud of the impeller is 80 per cent of the net pressure, the unbalanced thrust on the impeller, acting to the *left* is 1920 lb and the net force acting to the *right* is reduced to 13,152 or almost by 13 per cent. When the pump is standing idle on standby duty, however, this partial reduction disappears, and the end thrust returns to its former value of 15,072 lb. The pump thrust bearing, therefore, must be designed to accommodate this thrust.

In addition to radial flow impellers, mixed flow and axial flow impellers are commonly used. Except for very large sizes and certain special applications, maximum thrust, which may be developed by such impellers, is not of great importance since operating heads are relatively low.

In the case of axial flow impellers, there is an axial thrust caused by pressure imposed on the vanes as they act on the water. In addition, there is a difference in pressure acting on the shaft hub ends, one end being subject to discharge pressure and the other to suction pressure. Occasionally, provision is made in an axial flow pump for a leakage joint at or near the discharge hub periphery, with balancing holes through the hub. This construction occurs mainly in vertical wet pit pumps with covered shaft designs, in order that the seal at the lower end of the cover pipe be subjected to suction pressure rather than to discharge pressure.

In case of mixed flow impellers, axial thrust is a combination of forces caused by vane action on the water and forces arising from the difference in the pressures acting on the various surfaces. Providing wearing rings on the back side of mixed flow impellers and either balancing holes through the impeller hub or an external balancing pipe leading back to the suction are common practice.

In some designs of large mixed flow impellers as well as some high head vertical pumps with single suction radial type impellers, the leakage joint on the back side of the impeller has been made larger in diameter than the leakage joint on the suction side. Such a construction causes the axial thrust to act upwards balancing the rotor dead weight and tending to lift it upwards. This practice has fallen into disuse since more reliable thrust bearings have been made available.

Utilization of wearing rings on the

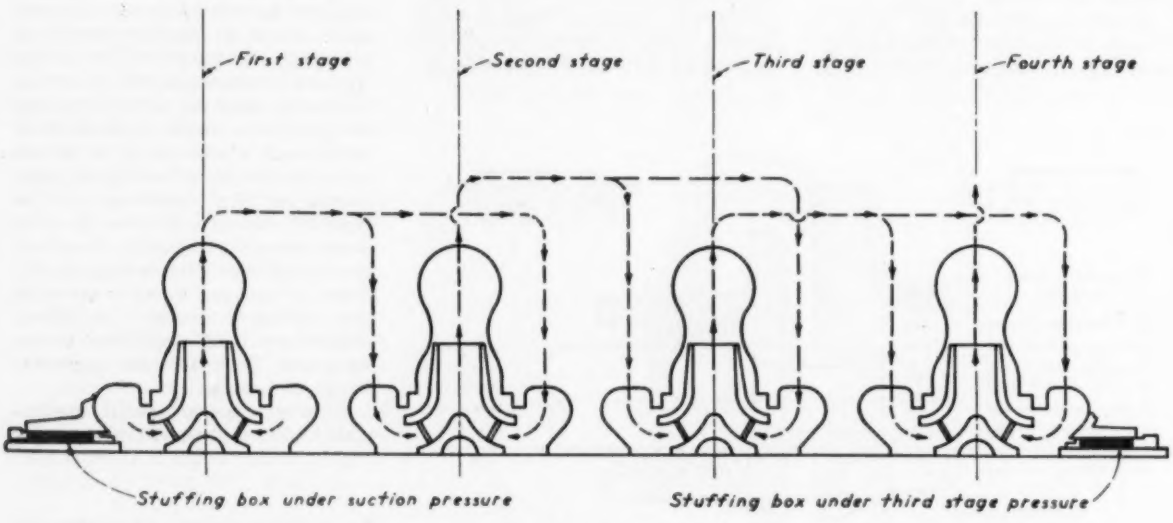


Fig. 7—Schematic diagram of a four stage pump with double suction impellers shows method of staging

back side of large capacity sewage pumps with mixed flow impellers does not meet with general approval. Therefore, this situation is seldom encountered, even though their absence leads to the necessity of larger capacity thrust bearings.

Virtual absence of unbalanced axial thrust and greater suction areas available in a double suction impeller would appear to be of sufficient advantage to apply such impellers to multistage pumps as well. This design, however, when applied to multistage units, contains certain definite shortcomings. The average multistage pump is of relatively low capacity when compared to the entire range covered by modern centrifugal pumps. As a result, using double suction impellers for the sole purpose of reducing net positive suction head required for a given capacity is seldom necessary.

Even if a double suction impeller becomes desirable for the first stage of a large capacity multistage pump, using such impellers for the remaining stages is hardly necessary. As to the advantages to be derived from the axial balance of a double suction impeller, a certain amount of axial thrust is present in all centrifugal pumps, and, therefore, the necessity of a thrust bearing is not eliminated.

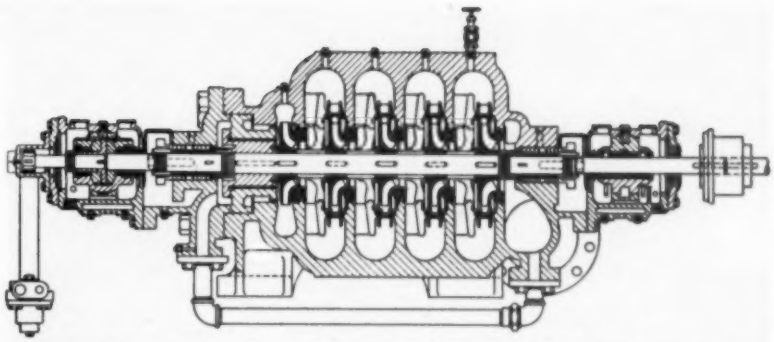


Fig. 8—Multistage pump with single suction impellers all facing in one direction has the axial thrust relieved by means of hydraulic balancing devices

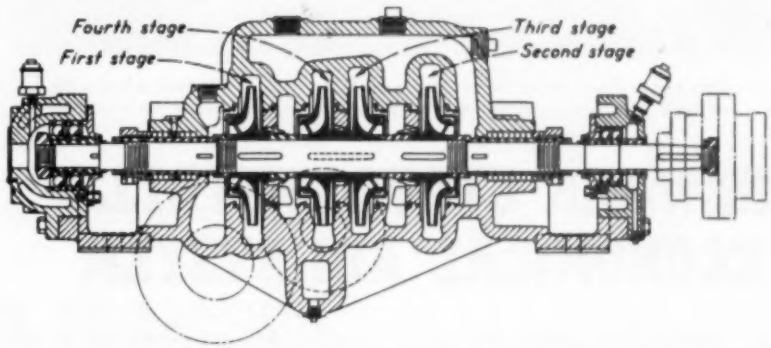


Fig. 9—Four stage opposed impeller pump has half the impellers facing in one direction, the other half in the other direction to balance axial thrust

Shaft Length

Shortcomings of double suction impellers in a multistage pump lie mainly in the fact that this construction adds needless length to the pump shaft span. Additional space is required for the extra passage leading to the second inlet of each successive stage. In the case of a pump with four or more stages, Fig. 7, this increase in shaft span becomes quite appreciable, to say nothing of the added casting difficulties. In the event the shaft diameter is increased to compensate for the longer shaft span so as to maintain a reasonable shaft deflection, the impeller inlet areas are correspondingly reduced. The margin of advantage of the double suction impeller design from the point of view of suction conditions becomes even less appreciable.

Finally, arranging the various impellers within a double suction multistage pump in any order other than the ascending order of the stages appears to be impractical. Furthermore, the impeller at one end of the casing is the last stage impeller, and the pressure acting on the adjacent stuffing box will be the discharge pressure of the next to last stage. To reduce this pressure, interposing some form of a pressure reducing bushing between the last stage impeller and the stuffing box becomes necessary. This, of course, would further increase the over-all length. As a result of these considerations, the majority of multistage centrifugal pumps are built with single suction impellers.

There are two obvious arrangements of single-suction impellers for a multistage pump:

1. Several single suction impellers may be mounted on one shaft, each of these impellers having its suction inlet facing in the same direction, the stages following each other in the ascending order of pressure, Fig. 8. Axial thrust is then balanced by a hydraulic balancing device.

2. An even number of single suction impellers can be mounted on one shaft, half of the impellers facing in a direction opposite to the second half. Thus, the axial thrust in one direction on half of the impellers is compensated by the thrust in the opposite direction acting on the second half, Fig. 9. This mounting of single suction impellers back to back is frequently referred to as "opposed impellers".

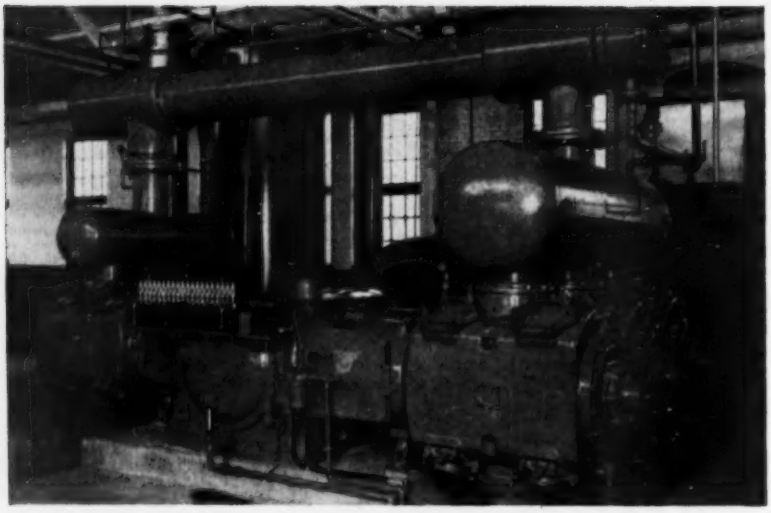
This last arrangement can be changed to use an uneven number of single suction impellers. The resulting axial unbalance must be taken care of by the proper choice of shaft and interstage bushing diameters. This gives the effect of a hydraulic balancing device to compensate the hydraulic thrust of one of the stages.

Once a multistage pump is balanced, by employing opposed impellers, the most satisfactory sequence in which individual stages are to be arranged within the pump casing is determined. There are three separate factors that enter into the analysis of a satisfactory stage arrangement, and the final solution must, perforce, become a compromise between the individual *best* solutions, each of which satisfies these three factors:

1. Pressure difference between any two adjoining stage chambers should be kept to the minimum possible, and several low pressure running joints are to be preferred to a fewer number of joints subject to a relatively high pressure.

2. Various stage impellers should be so arranged that the stuffing boxes will be subjected to the lowest pressure within the pump.

3. Sequences of stages should be such as to avoid excessive complications in forming interstage passages.



This compressor, installed at the Newark Stove Company, has a capacity of 4250 cfm and supplies air for general industrial plant consumption

NEWARK STOVE INSTALLS ECONOMICAL AIR SYSTEM

LATEST DEVELOPMENTS in efficient production of compressed air are incorporated in the new installation at the Newark Stove Co., Newark, Ohio. Many of these advanced operating features in effect stem from extensive experience in the fields of pipe line operation, refinery procedures, and diversified chemical processing. The simpler and less costly installation results from horizontally opposed piston design.

This type of inherently balanced design also effectively reduces the resultant effect of inertia forces that otherwise develop mechanical vibration under different load conditions. The more compact pancake-type construction of the horizontally opposed piston design further permits auxiliary equipment to be nested directly with the main unit, simplifying installation of piping and control equipment.

The compressor installed has the capacity for supplying 4250 cfm air for general industrial needs at 100 psi. The installation provides for drawing air through a filter into a surge tank mounted directly below the three low pressure cylinders. The low stage cylinders discharge into a header above the cylinders.

From the low pressure stage, the air passes through an intercooler where oil and moisture are condensed and removed. Air is then directed to a surge tank above and ahead of the two high pressure cylinders. Air delivery is made to a header mounted below the high pressure cylinders and in turn piped to an aftercooler. The remaining oil and water are removed before the air is piped to the receiver.

Quiet and efficient operation at all loads is assured by pneumatically operated unloading valves controlled from a master panel. This control governs the valve openings of each low and high pressure cylinder, keeping the compressor in uniform operating balance.

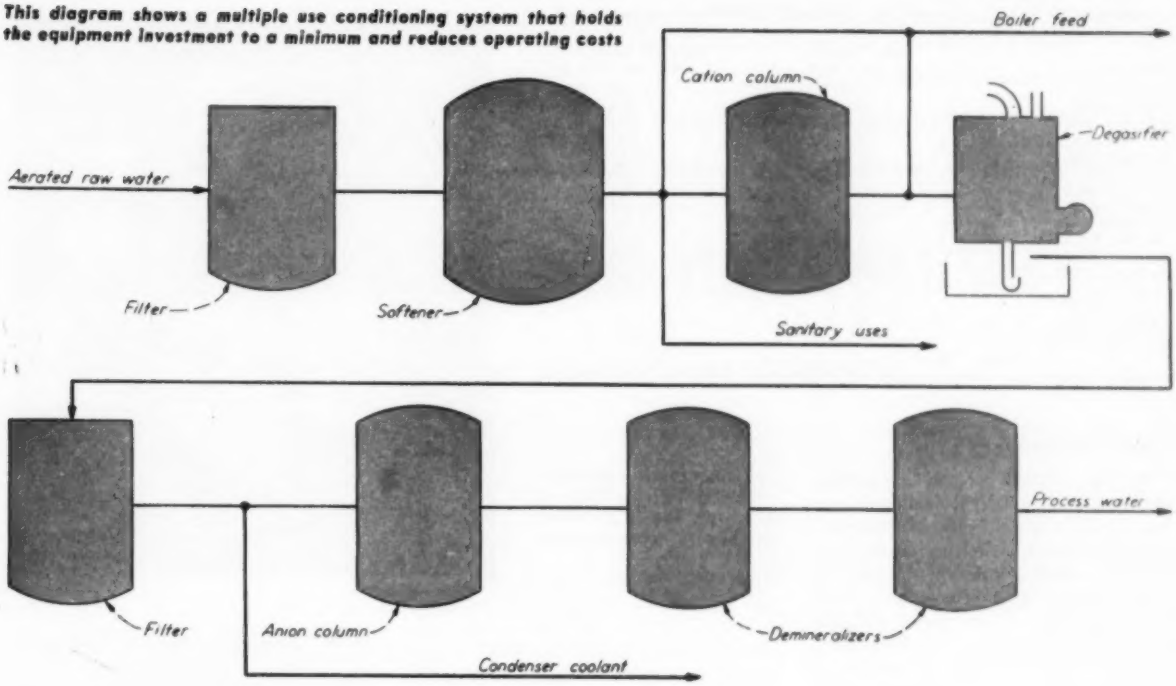
Pneumatically operated clearance pockets located in the head of each compressor cylinder effect complete 5-step control of output from 100 to 0 per cent. The 5-step unloading is achieved at constant crankshaft speed and is arranged so as to permit reversing the unloading cycle at any point without going through the complete unloading and loading sequence.

Lubricating oil for the crankcase and vital parts is circulated by an independent motor driven pump. Before starting up the compressor, this oil pump supplies lubrication to crankcase and crosshead members. This prevents the danger of premature wear on operating components otherwise possible when starting up heavy equipment that has been idle overnight.

Prime mover is an 800 hp, 450 rpm synchronous motor, which helps correct the line power factor and maintain a more favorable power factor.

Automatic control equipment governs the operation of the motor and compressor. Panel at the right controls pneumatically actuated unloading valves to satisfy all load conditions

Moisture and oil are removed in the aftercooler and receiver before the air is delivered to the plant system



This diagram shows a multiple use conditioning system that holds the equipment investment to a minimum and reduces operating costs

WATER SYSTEM PLANNING BECOMES AN EXACT SCIENCE

ANTHONY GIGLIOTTI
President
Penfield Mfg. Co., Inc.

WATER, the universal raw material, is indispensable to industry. While the chemist might need only one ounce of the purest water obtainable to run a critical test, many manufacturing operations require tremendous quantities of water. Thus, water supply has become one of the most important considerations in the selection of a plant site not only from the standpoint of quantity but also in terms of the critical factor of quality.

Generally speaking, water is needed for: (a) boiler feed, (b) cooling, (c) process operations, (d) drinking, (e) sanitary facilities, and (f) fire protection. Since treatment will vary with both raw water quality and end use, tailoring water to satisfy these diverse specifications has become an exact science.

System Planning

Many well managed companies are no longer solving water treatment problems on a piecemeal basis. Instead, individual surveys are conducted for each water consuming operation in the entire plant. Then all water treatment is considered as one separate and distinct function, completely independent of production. With this arrangement, separate units can be set up for filtering, settling, coagulating, softening, demineralizing or any other type of treatment that may be required. One man can control all operations, and with the new developments in automatic equipment such as self regulating, single column demineralizers, the most rigid water specifications can be maintained without interfering with production. Usually, substantial cost savings as well as increased operating efficiencies can be effected.

Recirculation

Where water is scarce, expensive, or needs a great deal of treatment, recirculation can bring about additional savings. Using water on a once through basis, unless absolutely necessary, is a wasteful practice. Circulating water over cooling towers or through sprays brings about enormous reductions in over-all consumption. For instance, one large chemical plant with 160,000 gpm cooling towers requires only 6 to 8 per cent makeup. Another manufacturer actually recirculates cooling water as many as 50 times before discharging it to waste.

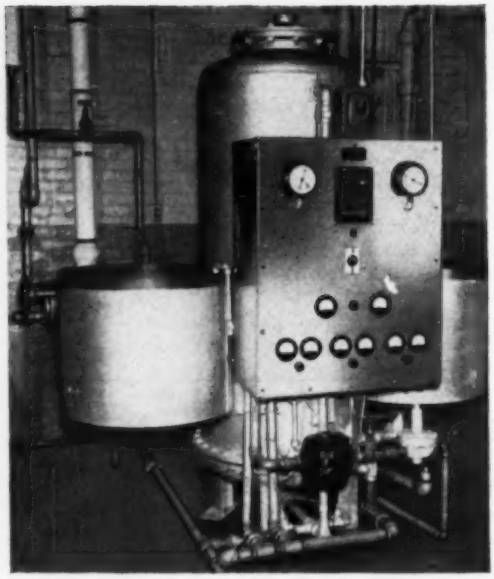
Re-use of process water also saves money. By re-filtering and demineralizing water used for processing, one plant cuts consumption from 230 to 4 mgd. Any place where water is used for extraction, the valuable liquid can usually be salvaged. For example, in making starch, steep water can be recycled completely, while many paper mills now recycle all of their white water. One board mill reports fresh water consumption per ton of pulp was reduced to 1000 gal by recycling methods while another mill making bleached pulp and re-using little of the mill water takes up to 50,000 gal.

Case Histories

Several surveys have been conducted to obtain case histories on the successful application of coordinated water conditioning systems. The industries selected are all prolific water consumers. Naturally, each plant has specific problems and will require treatment facilities engineered to its requirements, but these case histories reveal typical results of over-all planning.

APPROXIMATE CHEMICAL COSTS OF PURIFYING WATER BY ION EXCHANGE

Plant location	Water hardness as ppm $CaCO_3$	Cost of treatment in cents per 1000 gal
New York, N. Y.	15	1.7
Seattle, Wash.	25	3.4
Baltimore, Md.	40	4.6
San Francisco, Calif.	75	5.2
Memphis, Tenn.	100	6.9
Dallas, Texas	105	7.5
Detroit, Mich.	110	8.1
Chicago, Ill.	130	9.3
Cleveland, Ohio	135	9.9
Salt Lake City, Utah	155	11.1
Los Angeles, Calif.	215	15.9
San Diego, Calif.	235	17.2
Austin, Texas	240	17.8
Kansas City, Mo.	240	17.8
Madison, Wisc.	300	21.7
Kalamazoo, Mich.	500	39.7



Fully automatic operation including regeneration of the resin bed is provided by modern demineralizers

Typical Brewery

A large eastern brewery producing an average of 1800 barrels of beer per day (actually, production is somewhat seasonal, higher than this average in summer, lower in winter) was selected as an example of the beverage industry. This plant utilizes about 450 gal of water per barrel of beer produced, or a total of 810,000 gal of water per day. Water is used for: (a) processing or "brew" water, (b) cooling, (c) bottle washing, keg cooling and pasteurizing, and (d) boiler feed. Raw, fresh river water is employed for cooling and boiler feed and no recirculation is required, while municipal services supply the brew and wash water.

In general, brew water must be clear, odorless, tasteless, and free of iron and manganese. Of course, it must be bacteriologically acceptable as well. This particular plant produces light or Pilsener type beer, which requires brew water that is low in bicarbonates, high in sulfates. Therefore, lime is added to keep the bicarbonates down, calcium sulfate (200 ppm) to keep sulfate content high, the operation being carried out in a cold lime water softener. Before the softening step, the water is aerated to remove iron and manganese and activated carbon filters are employed to insure the elimination of foreign odors or taste. Final treatment consists of putting the brew water through sand filters.

Water for bottle washing and high pressure steam boiler feed is treated to zero hardness in a battery of automatic demineralizers. By demineralizing the wash water, the cost of detergents is reduced 50 to 75 per cent. Unsightly surface deposits are eliminated and no glass polishing is necessary.

Chemical Plants

Many chemical plants require vast quantities of water, particularly for cooling. This service may consume as much as 80 to 90 per cent of the total, although other uses include processing, either as makeup or for purification by crystallization, washing, scrubbing of gases, boiler feed, drinking, sanitary purposes, and fire protection.

Purity, of course, is the keynote to product quality in the chemical industry. This is especially critical in the manufacture of chemically pure reagents, pharmaceuticals and drugs. For these operations, the water should be clear and free from metals, sulfur, and organic growths.

In the past, distilled water was used extensively for the production of chemically pure materials. Since distilled water costs $2 to $6 per 1000 gal in single effect evaporators and $0.50 to $1.25 for quadruple effect units, demineralizers are replacing distillation columns. Demineralized water costs only about $0.15 per 1000 gal. In addition, modern units permitting completely automatic anion and cation exchange in a single column, even to the regenerative cycle and recutting in the effluent, simplify operations.

Pharmaceutical Plant

Another case history was obtained from studies of a moderate sized pharmaceutical plant where total water requirements are approximately 90,000 gal per day. Raw well water, 347 ppm hardness ($CaCO_3$) and 187 ppm alkalinity (methyl orange), supplies all services. General needs are: (a) boiler feed, (b) sanitary facilities, (c) cooling, and (d) processing.

Since the raw water contains appreciable amounts of hydrogen sulfides, it is first aerated to precipitate the sulfides as sulfur. Then a sand filter removes the sulfur before the water passes through a softener. At this point, water of sufficient softness is drawn off for sanitary purposes.

About 3000 gph of softened water flows to a large cation column where cations are removed and the 187 ppm of alkalinity are converted to carbonic acid, which can be blown from the water into a degasifier as CO_2. Water from the cation column is combined with equal parts of water from the softener to make a good blend for boiler feed. Degasified water is then passed through another sand filter and on to the anion column. About 100 gph is drawn from this point, demineralized down to about 20 ppm total solids, treated with caustic and used as makeup water for a condenser coolant.

The rest of the water passing through this multiple use treating system goes to a battery of demineralizers, which deliver about 2500 gph of high quality water. In this plant, water with purity in excess of one million ohms conductivity is required to process the pharmaceutical product.

Because the tendency today is toward the use of high pressure steam boilers, water treatment becomes more important than ever in order to prevent costly and troublesome scale formation and corrosion. Water softening methods including the zeolite systems and hydrogen cation exchangers as well as the lime-zeolite and hot-lime-soda processes all have been applied successfully to this service. Single and multiple column demineralizers also are enjoying growing favor for the treatment of water for high pressure boilers, often in conjunction with techniques of filtration, sedimentation or coagulation, depending upon particular water and service conditions.

Power transmission

Engineering data and information to aid in selection, application and operation of equipment used in transmission of mechanical power

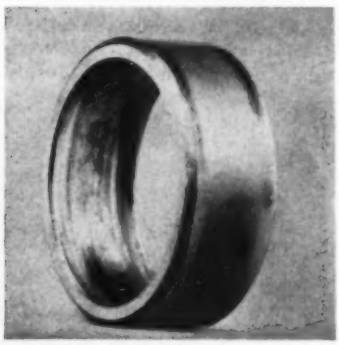
BEARING FAILURES AND THEIR CAUSES

JOSEPH L. BRUSCA, *Senior Design Engineer, SKF Industries, Inc.*

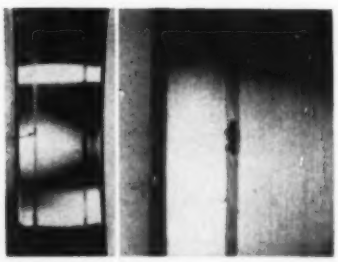
BEARING ENGINEERS must know the reasons for a bearing failure before it can be corrected. While ball and roller bearings have proven by long experience to be reliable and to need little attention, the principles governing their applications are necessarily quite different from those applicable to plain bearings. Therefore, locating the cause for a bearing failure is of utmost importance.

Sometimes, this can be done very quickly by inspection of the bearing and the condition surrounding the application. Other times, a complete laboratory examination is necessary before the cause can be determined. In addition, there are times when the actual cause of failure cannot be definitely established, and an exhaustive study of the application and all surrounding conditions must be made.

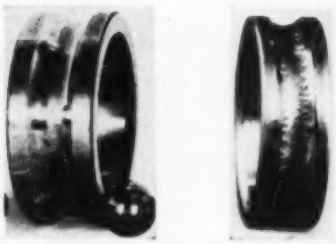
Of course, there are common conditions of bearing failures that may be linked with the type of application. The following causes of early failure and suggested remedies will aid the engineers in prolonging the life of such bearings.



Wear caused by foreign matter



Early stages of flaking magnified



Flaking in the advanced stages

Failures Due to Dirt and Other Foreign Matter

One common cause of bearing failure is dirt. Failure because of dirt can be recognized in several ways. Generally, fine dirt in a bearing acts as an abrasive and results in lapping of the various parts. This can be seen and felt in the ball or roller paths of the self-aligning type bearing. These paths will be polished along with the balls and rollers. When no breaks appear on the surfaces of rolling elements and the ball or roller path is clearly defined, fine dirt has entered the housing during service.

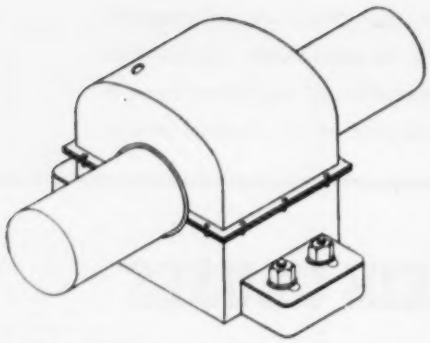
Deep groove-type bearings are not as easily examined since the ball paths and balls cannot be readily seen. A preliminary check can be made by feeling the amount of clearance between the inner and outer races. This can be done by laying the bearing on a flat surface and holding one ring stationary. When the other ring can be moved in a position parallel to the flat surface, wear has taken place. This wear cannot be felt when the bearing is held by hand. In this position, the normal internal clearance can be felt, and this might be mistaken for wear.

Ball and roller bearings do not wear, even after long service, when kept clean and lubricated properly. However, as they reach their fatigue-limit, flaking of the loaded areas occurs. This flaking is not considered wear in the same sense as wear caused by abrasives. Many worn bearings, of necessity, have to be discarded long before the fatigue-limit of the steel is reached.

If water or other corrosive agents enter the bearing, wear might occur

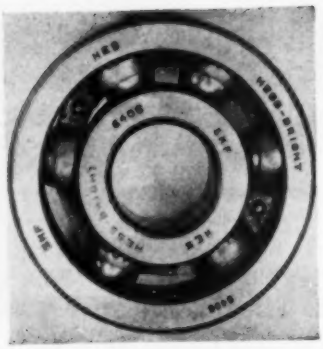
This is the general appearance of corrosion

Corrosion at points of contact between parts



This shroud or metal box encloses the bearing housing and offers protection

Overheating and tempering causes early flaking



Eccentric wear of retainer caused by poor lubrication and foreign matter

quickly. Iron oxide formed by rust is an abrasive and will lap or grind the balls or rollers making them undersize. Sometimes a bearing will become corroded even before placed into service. A motor, pump, or machine may be flooded, or water may be introduced with the lubricant. In such an instance, corrosion pitting will occur that is distinguished by a dark brown color. This pitting will be found where the balls or rollers contact the faces. This might cause bearing noise even though the machine has just been put into service.

If examination of a bearing indicates that wear has taken place, the actual application should be carefully checked. Quantities of hard, gritty particles, such as produced by a grinding wheel or a buffing stand might be found. Seals should be checked thoroughly to make sure that dirt is not going past the seals into the bearing. The lubricant should be inspected as well as the lubrication method. Slipshod maintenance methods could be a reason for contaminated lubricant.

Sometimes a simple inexpensive shroud or sheet metal box can be employed to deflect dirt away from the bearing house. This procedure will pay for itself many times over.

Similar results are obtained with respect to water or other corrosive agents entering the bearing housing. Everything possible should be done to deflect fluids away from openings.

Another form of foreign matter is chips or particles of steel through failure of machine parts—such as a gear. Such chips in the ball path will be pressed into the races and balls causing dents or scratches.

Failures Due to Inadequate or Improper Lubrication

One common cause of early failure is inadequate or improper lubrication. The amount of lubricant required by a ball or roller bearing is small. That is why so many of these bearings, unlike the majority of plain bearings, can be lubricated with grease. Yet, while the amount required may be small, the quality should be the best obtainable.

Some applications involving high temperatures, high speeds, and heavy loads require oil lubrication. In some instances, special methods are employed, such as *circulating oil, oil mist,* and *drop feed.*

Lack of lubricant is revealed by a high pitch sound and a rapid rise in temperature. (A rise in temperature can also be the sign of over-lubrication). Failure to correct this fault immediately is apt to be followed by different kinds of damage. Intense overheating will draw the temper of the bearing steel, and the bearing will fail quickly. This condition can be recognized by the color of the bearing, and in the early stages it will be blue. If the bearing continues to operate, seizure may occur resulting in damage to other parts.

Lack of lubricant may cause cage wear, which is accompanied by smearing of the balls or rollers and their tracks in the rings.

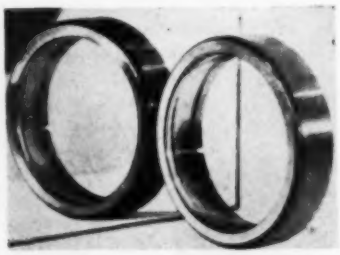
Too solid a grease or too thick an oil is capable of producing a braking effect powerful enough to make the rolling elements slide. Such sliding will cause smearing of the effected parts, and early failure might occur.

Rapid starting of a machine is an adverse condition for an anti-friction bearing. Where the load is heavy, a smearing condition can occur because of sliding parts before the running temperature has been reached and while the grease is still solid. This is particularly true where bearings operate under low temperature conditions. Where the load is light, the inner race slides or skids on the balls or rollers before they have a chance to rotate, and smearing again takes place. Under either condition, the bearing will continue to operate but will be noisy and eventually will fail.

Results of defective lubrication or lack of lubrication

Flaking from smearing due to defective lubrication

Improper lubrication smearing of flange and roller parts



Failure of bearing ring caused by distortion of the ring by housing

Only B. F. Goodrich makes the grommet belts that cut costs 20 to 50%!

Save 3 ways! Investigate today! Write or mail coupon

You save belt costs because belts last longer, save production costs because machines keep running with fewer interruptions, save maintenance costs because they need less attention.

Patented grommet belts by B. F. Goodrich represent the only basic change since invention of the V belt. Belts last 20 to 50 per cent longer, depending on service. (The more severe the service, the greater the increase over ordinary belts.) Grommet belts have more rubber; they're more flexible, give better grip, less slip.

What is a grommet?

A grommet is like a giant cable except that it's *endless*—a cord loop built up by winding heavy cord on itself. There is no overlapping cord *section* as in all ordinary belts. Most belt failures occur in these sections where cords overlap!

All cords put to work

Each of the two grommets and every part of a grommet carry their share of the load. In ordinary belts under high tension the center cords "dish" because tension is greater near the driving faces. Dished cords are doing less work, not pulling their share. Grommet belts have no center cords, there is no dishing—therefore much more strength in proportion to cord volume—and less stretch. Grommet belts stretch, on an average, only about one-third as much as ordinary belts.

Better grip, less slip

Grommet belts have more rubber in relation to belt size. Without any stiff overlap, they're more flexible, grip pulleys better. Size for size, grommet belts give ⅓ more gripping power, pull heavier loads with a higher safety factor. Because there is less slip, there is also less surface wear.

Send for proof

Send the coupon for a set of reports telling users' experiences and showing actual installations where grommet belts outlasted all others. Some typical cases:

"... within a few days ordinary belts had stretched ... After six months of 24-hour-a-day service BFG grommet belts haven't stretched at all ..."

"Ordinary belts lasted only 5 or 6 weeks ... B. F. Goodrich grommet belts are in their sixth month of service ..."

"Previous belts suffered from shock loads, wore out fast ... BFG grommet belts have been in service 2 years with no shut-downs..."

There are hundreds of cases like these.

They cost no more

BFG grommet belts cost not one cent more than others. The savings they make for you are clear profit. They are made in C, D and E sections. They are patented by B. F. Goodrich. No other V belt is a grommet belt (U. S. Patent No. 2,233,294).

Write, send the coupon or see your B. F. Goodrich distributor. (He will show you his "X-ray" belt that shows the grommet construction clearly.)

Grommet V-Belts BY

B.F.Goodrich

FIRST IN RUBBER

The B. F. Goodrich Company
Dept. IP-1
Akron, Ohio

☐ Send set of reports telling users' experiences and showing actual installations proving that B. F. Goodrich grommet belts outlast all others.

☐ Have distributor show me the "X-ray" belt that shows how B. F. Goodrich grommet belts are made.

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How to make packings last longer

Tips by Johns-Manville Engineers to help you keep production rolling

...and this new chart makes it easy to choose the right J-M Packings for your power plant equipment

A handy 6-page guide, "Johns-Manville Packings for the Power Plant" simplifies the selection and application of power plant packings. Covering 32 of our most popular styles, it tells at a glance what J-M packings to use... why they are recommended... and how to install them.

Its schematic diagram is spot-keyed to help you locate packing styles for various equipment units. Its brief group-headings help you select J-M packings for centrifugal and rotary services, reciprocating rods and plungers, valve stems, pipe flanges, manholes and handholes... to seal against steam, water, oil, brine, etc.... to withstand various temperatures and pressures. Its condensed packing descriptions give you essential buying information.

And a page is devoted to tips on proper installation to help you get maximum economy and efficiency from your Johns-Manville packings.

Your local Johns-Manville Packing Distributor will be glad to give you a copy of this handy packing selector, free of charge. Or write to Johns-Manville, Box 60, New York 16, N. Y., asking for Brochure PK-61A. In Canada, address 199 Bay Street, Toronto 1, Ontario.

JOHNS-MANVILLE JM PRODUCTS

Johns-Manville PACKINGS & GASKETS

Handbook for engineered plant services

Methods, data and ideas that make excellent references in solving engineering problems frequently encountered in plant operations

LOCATING AND CORRECTING CENTRIFUGAL PUMP TROUBLES

Acknowledgment is made to the Allis-Chalmers Manufacturing Co. for data contained in this edition of the Handbook for Engineered Plant Services.

NO LIQUID DELIVERED

1. Lack of prime	Fill pump and suction completely with liquid
2. Speed too low	Check whether motor is connected directly across the line and receiving full voltage. Frequency may be too low, and the motor may have an open phase. When turbine driven, check governor setting and throttle valve.
3. Discharge head too high	Check pipe friction losses. Larger piping may correct condition. Check to see if valves are wide open.
4. Suction lift too high	If no obstruction at inlet, pipe friction losses should be checked. However, static lift may be too great. Measure with mercury column or vacuum gage while pump operates. When static lift is too high, water to be pumped must be raised or pump lowered.
5. Impeller completely plugged	Remove bearing bracket assembly and clean impeller.
6. Wrong direction of rotation	This sometimes occurs. Compare motor rotation with directional arrow on pump casing.

NOT ENOUGH LIQUID DELIVERED

7. Air leaks in suction piping	When liquid pumped is water or other non-explosive—and explosive gas or dust is not present — flanges can be tested for leakage with flame or match. For liquids, such as gasoline, suction line can be tested by shutting off or plugging inlet and putting line under pressure. A gage will indicate a leak with a drop of pressure.
8. Speed too low	Check whether motor is connected directly across the line and receiving full voltage. Frequency may be too low, and the motor may have an open phase. When turbine driven, check governor setting and throttle valve.
9. Discharge head too high	Check pipe friction losses. Larger piping may correct condition. Check to see if valves are wide open.
10. Suction lift too high	If no obstruction at inlet, pipe friction losses should be checked. However, static lift may be too great. Measure with mercury column or vacuum gage while pump operates. If static lift is too high, water to be pumped must be raised or pump lowered.
11. Impeller partially plugged	Remove bearing bracket assembly and clean impeller.

PUMP TAKES TOO MUCH POWER

12. Not enough positive suction head for hot or volatile liquids (Can be determined with gage. When the liquid is flashing, the gage jumps)	Hot liquid cannot be lifted very high—and extremely hot liquid cannot be lifted at all. In many cases, the pump suction must be considerably lower than the source of hot liquid so the liquid will flow in under pressure. Pressure required depends on temperature of liquid, pump capacity, and type impeller. Safest solution is to consult with pump manufacturer.
13. Defective wear plates	Inspect. Replace if worn excessively.
14. Defective impeller	Inspect. Replace if damaged or vane sections badly eroded.
15. Defective packing	Replace packing and sleeves when badly worn.
16. Foot valve too small or partially obstructed	Inspect. Area through ports of valve should be at least as large as area of suction pipe—preferably 1½ times. If strainer is used, net clear area should be 3 to 4 times area of suction pipe.

17. Suction inlet not immersed deep enough	When inlet cannot be lowered—or if swirling eddies through which air is sucked persist when it is lowered—chain a board to suction pipe. It will be drawn into eddies, smothering the vortex.
18. Wrong direction of rotation	Compare motor rotation with directional arrow on pump casing.

NOT ENOUGH PRESSURE

19. Speed too low	Check whether motor is connected directly across the line and receiving full voltage. Frequency may be too low, and the motor may have an open phase. When turbine driven, check governor setting and throttle valve.
20. Air or gases in liquid (Test in laboratory, reducing pressure on liquid to pressure in suction line. Watch for bubble formation)	May be possible to overrate pump to point where it will provide adequate pressure despite condition. Better to provide gas separation chamber on suction line near pump and periodically exhaust accumulated gas.
21. Mechanical defects	Inspect wear plates and replace if worn excessively, and replace impeller if damaged or vane sections are badly eroded. Replace packing and sleeves when badly worn.
22. Obstruction in liquid passages	Remove bearing bracket assembly and inspect passages of impeller and casing. Remove obstruction.
23. Impeller diameter too small (probable cause, if none of above)	Check with your pump manufacturer to see if a larger impeller can be used. Otherwise, cut pipe losses or increase speed or both as needed. But, be careful to not seriously overload the drive.

PUMP WORKS FOR A WHILE AND QUITS

24. Incomplete priming	Free pump, piping, and valves of all air. If high points in suction line prevent this, they should be corrected.
25. Suction lift too high	If no obstruction at inlet, pipe friction losses should be checked. However, static lift may be too great. Measure with mercury column or vacuum gage while pump operates. When static lift is too high, water to be pumped must be raised or pump lowered.
26. Air leaks in suction piping	When liquid pumped is water or other non-explosive—and explosive gas or dust is not present—flanges can be tested for leakage with flame or match. For liquids, such as gasoline, suction line can be tested by shutting off or plugging inlet and putting line under pressure. A gage will indicate a leak with a drop of pressure.
27. Air or gases in liquid	May be possible to overrate pump to point where it will provide adequate pressure despite condition. Better to provide gas separation chamber on suction line near pump and periodically exhaust accumulated gas.
28. Head lower than rating, pumps too much liquid	Turn down impeller's outside diameter to size advised by pump manufacturer.
29. Liquid heavier than originally specified (in either viscosity or specific gravity)	Use larger driver. Consult pump manufacturer for recommended size. Test liquid for viscosity and specific gravity.
30. Wrong direction of rotation	Compare motor rotation with directional arrow on pump casing.
31. Stuffing boxes too tight	Release gland pressure and tighten reasonably. When sealing water does not flow while pump operates, replace packing. When packing is wearing too quickly, replace scored shaft sleeves and keep water seeping to provide lubrication.
32. Casing distorted by excessive strains from suction or discharge piping	Check alignment. Examine for friction between impeller and casing and worn wearing plate. Replace damaged parts.
33. Shaft bent due to thermal distortion, damaged while overhauling, or improper assembly of rotating element	Check deflection by turning between lathe centers. Total run-out should not exceed 0.006 in. on low speed pump and no more than 0.003 in. on high speed unit.
34. Mechanical failure of critical pump parts	Check bearings, wearing plates, bushings, and impeller for damage. Any irregularity in these parts will cause a drag on the shaft.
35. Misalignment	Realign pump and driver.
36. Speed may be too high (brake horsepower of pump varies as the cube of the speed; therefore, any increase in speed means considerable increase in power demand)	Check voltage on motor and governor on turbine or engine.
37. Electrical defects	Voltage and frequency of the electric current may be lower than that for which the motor was built, or there may be defects in the motor. The motor may not be ventilated properly due to a poor location.
38. Mechanical defects in turbine, engine, or other type of drive exclusive of motor	When trouble cannot be located, call in factory service engineer.

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New Equipment begins Page 8	*New Bulletins begins Page 128*	*Advertised Products begins Page 109*
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Readers' guide to advertised products

This department is both a product index for advertising and a keyed listing for advertised literature. Refer to advertisement on page indicated and contact advertiser directly—or list paragraph key numbers on reader service card (page 107) to get data you want

AIR & DUST FILTERS & COLLECTORS

Dust Collectors

Aerotec Corp. series mechanical electrical dust collectors described on p 115. The Thermix Corp.

Dust Collection **500**

Information contained in booklet "The Collection and Recovery of Industrial Dusts". Buell Engineering Co. p 48.

Dust Control Systems **501**

Literature available on Kirk & Blum dust control systems. The Kirk & Blum Mfg. Co. p 129.

Dust & Fly Ash Recovery **502**

Booklet outlines principles of Multiclone centrifugal dust recovery. Western Precipitation Corp. p 121.

Electrical Precipitators **503**

Bulletin 500 contains facts on the Cottrell precipitator. Research Corp. p 38.

ANTI-CORROSIVE & PROTECTIVE COATINGS

Rust Preventive **504**

Adv. p 39 contains coupon for complete information on Rust-Oleum sealing compound. Rust-Oleum Corp.

BOILERS & BOILER ACCESSORIES

Steam Generators **505**

Information available on Wickes steam generators. The Wickes Boiler Co. p 59.

Deaerators **506**

Complete information available on American Jet-Tray deaerators. American Water Softener Co. p 133.

Boilers **507**

Catalog describes Types KS and KL boilers by The Bigelow Company. p 127.

Water Gages **508**

Bull WG-1811 describes Yarway flat glass gages that may be equipped with Type "M" illuminator that shines like a star. Yarnall-Waring Co. p 47.

BUILDING HEATING, VENTILATING, AIR CONDITIONING & REFRIGERATION

Unit Heaters

Adv. p 123 contains information on Trane unit heaters and diffusers. The Trane Co.

Humidity Control

Adv. p 116 describes Niagara's controlled humidity method using Hygrol moisture-absorbent liquid. Niagara Blower Co.

BUILDING MATERIALS & MAINTENANCE

Thread Compound **510**

Free sample and data sheet on Fel-Pro C-5 "Hi-Temp" thread compound. Felt Products Mfg. Co. p 139.

Iron Cement **511**

Free Repair Handbook describes Smooth-On repairs. Smooth-On Mfg. Co. p 126.

Metal Grating **512**

Free booklet "Instructions for Laying Klemp Hexsteel and Floorsteel". Klemp Metal Grating Corp. p 134.

Vacuum Cleaning Equipment

Adv. p 126 contains information on Hoffman heavy-duty vacuum cleaning equipment. U. S. Hoffman Machinery Corp.

Floor Patch **513**

Coupon on page 138 offers complete details of trial order plan and Handbook of Building Maintenance. Flexrock Co.

COAL, ASH & BULK HANDLING

Coal & Ash Handling Equipment **514**

Coupon on p 26 offers literature on coal firing, handling, and control equipment. Canton Stoker Corp.

Conveyers **515**

Additional information available on Jeffrey apron conveyers and feeders. The Jeffrey Mfg. Co. p 14, 15.

Coal Handling Equipment

Adv. p 3 contains information on the Link-Belt conveyer system. Link-Belt Co.

COMPRESSORS

Air Compressors **516**

Catalog 5110-A contains the complete Schramm story on stationary air compressors. Schramm, Inc. p 125.

CONTROLS, REGULATORS & INSTRUMENTS

Temperature Control

Adv. p 41 contains information on automatic temperature and humidity control for heating, ventilating, air conditioning and process control. The Powers Regulator Co.

Tank Gage **517**

Details available on Liquidometer tank gage. The Liquidometer Corp. p 138.

Temperature Control **518**

Cat 700-13 contains data on Sarco self-operated cooling controls. Sarco Co., Inc. p 21.

Regulators **519**

Bulletin contains complete data on Spence pressure and temperature regulators. Spence Engineering Co. p 46.

Feed Water Meters

Details available on Henszey feedwater meters. Henszey Co. p 117.

Pressure Controls **520**

Catalog 700A contains complete data on Mercoid DA pressure controls. The Mercoid Corp. p 139.

Regulators **555**

Bull 464 describes Leslie temperature regulators. Leslie Co. p 119.

DIESELS

Diesels

Adv. p 27 describes the supercharged, aftercooled Cooper-Bessemer JS-8 type diesel. The Cooper-Bessemer Corp.

ELECTRICAL DISTRIBUTION

Dual-Element Fuses **509**

Coupon in adv. p 18, 19 offers complete facts on Fusetron dual-element fuses. Bussmann Mfg. Co.

Fuses **521**

Price list and catalog on "Economy Delay" renewable fuses. Economy Fuse & Mfg. Co. p 58.

(Continued on page 112)

PRODUCT INDEX

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Tools 115
Transformers 115
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How to Combat

with Dearborn's complete water treatment and engineering service

Providing trouble-free water—a vital necessity to every user of steam—has been Dearborn's business for more than 65 years.

Today, this broad background of experience—plus treatment formulas that have been tested and re-tested and the most modern laboratory and research facilities—are available to you at Dearborn.

To keep your power and steam-producing facilities at peak production... to greatly minimize unnecessary maintenance—call your Dearborn Sales Engineer. He's our expert who will check your facilities—analyze your raw water—recommend the proper treatment, feeding equipment and test procedure. Dearborn Bulletin 5000 completely describes this service.

with Dearborn Engineered treatment equipment

Plus results from water treatment frequently depend on feeding equipment.

Here, too, Dearborn can help you. Your Dearborn Sales Engineer will inventory your existing equipment... your plant layout...then make recommendations to help you increase efficiency by including a pump or timer...a test cabinet...or an automatically controlled feeding system. Ask for Bulletin 5000.

Dearborn

TRADE MARK

COMBATTING CORROSION EVERYWHERE SINCE 1887

DEARBORN CHEMICAL COMPANY · Merchandise Mart Plaza, Chicago 54, Illinois

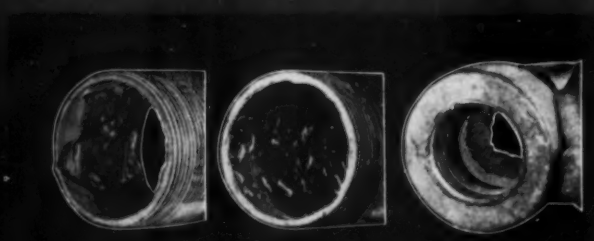
Water Problems

with Dearborn polyamide anti-foams

Equipment-damaging sludge formations in feed lines, heaters, generators can be eliminated with Dearborn Polyamide Anti-Foam No. 659. Prevents carry-over of suspended and dissolved solids... conditions sludge ... is compatible with other treatment. Dearborn Bulletin 5008 demonstrates how you can have this purer steam.

Greater Pittsburgh airport is protected by Dearborn's anti-corrosion services

To eliminate corrosion and reduce maintenance expense, the new, greater Pittsburgh Airport relies on many Dearborn water treatment and rust preventive products and services. Your Dearborn Sales Engineer will do the same for you... call him... no obligation, of course.



with Dearborn Filmeen to prevent return line corrosion

Replacement of valuable parts—destroyed after but a short service life—could have been prevented with Dearborn Filmeen... an exclusive Dearborn development that forms a continuous amine-type film on return lines to prevent corrosion. Dearborn Bulletin 5013 tells the complete story.

DEARBORN ALSO SUPPLIES

- **New, High-Capacity Exchange Minerals**
- **De-Ionizing Systems and Zeolite Softeners**
- **Dearsol—The New Fuel Oil Additive**

Dearborn Chemical Company, Dept. INP
Merchandise Mart Plaza, Chicago 54, Ill.

Please send me:

☐ Bulletin 5000 ☐ Bulletin 5013
☐ Bulletin 5008 ☐ Have a Dearborn Sales Engineer call

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Company.....

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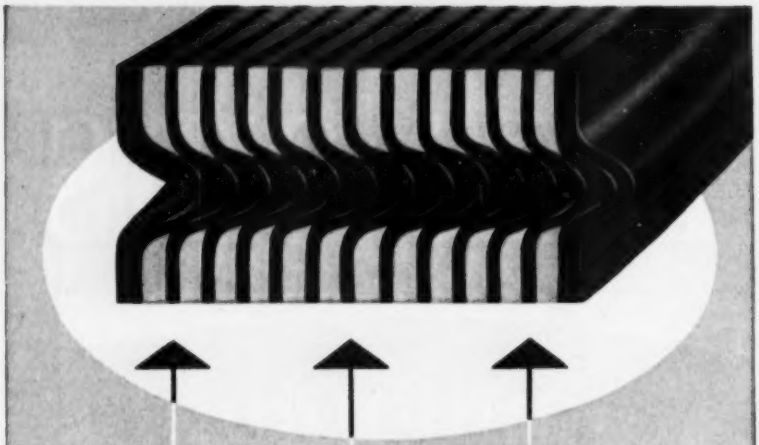


Every Gasket an EXPANSION JOINT

Ajax Spiral Wound Gaskets are literally just that. The live-spring action of the U-shaped metal plies—like the convolutions of tiny expansion joints—give and take with varying pipe line or boiler stresses to seal joints tight at safe bolt loads, and keep them tight under all operating conditions.

There are types and sizes for all standard flanges and for manholes, handholes and tube caps of all makes of stationary and marine boilers, waterwalls, economizers and other boiler accessories.

Materials of construction include plated low carbon steel or stainless, Canadian or Blue African asbestos or chemically inert Teflon. Sold universally through industrial distributors. Ask your supply house or write—

UNITED STATES GASKET COMPANY

FABRICATORS OF "TEFLON" & "KEL-F" FOR THE CHEMICAL PROCESS & ELECTRONIC INDUSTRIES

CAMDEN 1 NEW JERSEY

Readers' guide to advertised products

(Continued from page 109)

Load Center System **522**
Bull GEA-3502 contains data on G-E load-center system. General Electric Co. p 28, 29.

Metal-Clad Switchgear **523**
Bull 7004-B contains complete details on I-T-E Metal-Clad switchgear. I-T-E Circuit Breaker Co. p 10, 11.

ENGINES

Engines
Adv. p 54 contains data on Worthington dual fuel engines. Worthington Corp., Engine Div.

FUELS & FIRING EQUIPMENT

Coal
See adv. p 37 for information on bituminous coal. Bituminous Coal Institute.

RotoGrate Stokers **524**
Bulletin contains information on Detroit RotoGrate stokers. Detroit Stoker Co. p. 35.

HEAT EXCHANGER EQUIPMENT

Deaerators
Adv. p 56 contains information on Worthington deaerators. Worthington Corp., Steam Power Div.

Instantaneous Water Heaters **525**
Engineering data available on instantaneous water heaters. Pick Mfg. Co. p 122.

Water Heaters
Adv. p 36 contains data on P-K hot water storage heaters. The Patterson-Kelley Co., Inc.

Condensers **526**
Bulletin RC-1 contains data on Vogt horizontal and vertical types shell and tube condensers for every service. Henry Vogt Machine Co. p 113.

LUBRICANTS, LUBRICATION, OIL FILTERS & PURIFIERS

Rubilene Oil
Adv. p 55 contains data on Sinclair Rubilene oil. Sinclair Refining Co.

Lubricant
Adv. p 51 describes Standard HD oil. Standard Oil Co. (Indiana).

Lubricant **527**
"Lubriplate Data Book", a valuable treatise on lubrication. Lubriplate Div., Fiske Brothers Refining Co. p 140.

Lubricant
Adv. p 142 contains data on Texaco Ursa oil. The Texas Co.

MECHANICAL POWER TRANSMISSION

Variable Speed Pulleys **528**
Catalog and engineering data available on Lovejoy variable speed pulleys. Lovejoy Flexible Coupling Co. p 136.

(Continued on page 114)

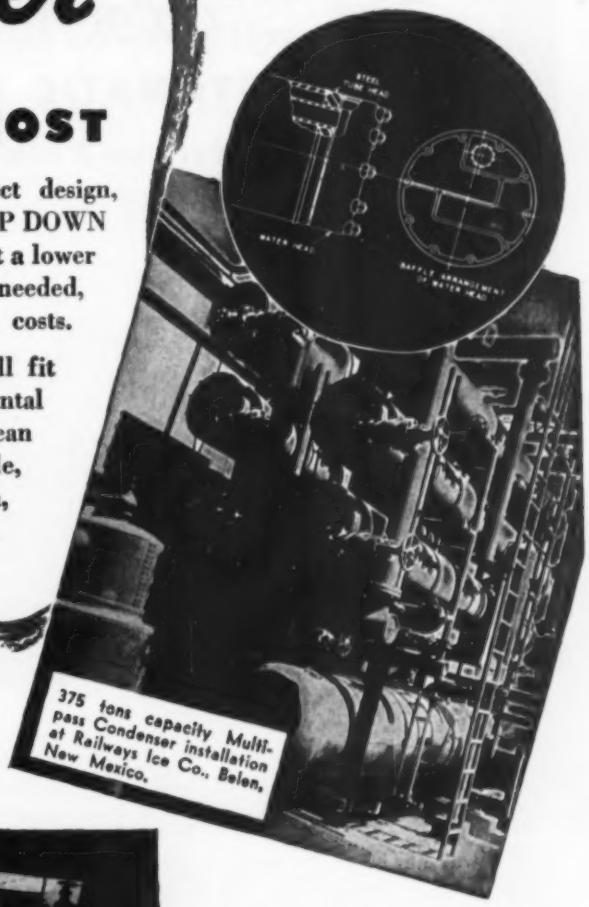
$ave Power and REFRIGERATION COST

Vogt Condensers, because of their correct design, STEP UP the rate of heat transfer and STEP DOWN head pressures. With the liquid delivered at a lower temperature, smaller compressor capacity is needed, saving in original as well as operating costs.

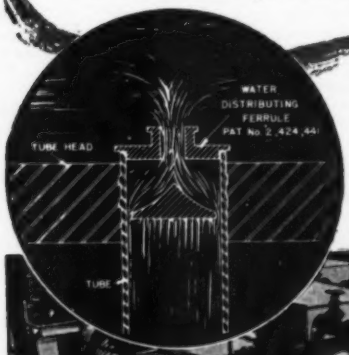
One of the two basic types illustrated will fit your operations exactly. Install Horizontal Multipass (closed type) for use with clean waters. Where the water is hard, forms scale, contains mud or promotes fungus growth, Vertical Single Pass (film type) which can be cleaned in operation, are recommended.

Horizontal Multipass Condensers
(Closed Type)

Water circulated in tubes traverses the length of the unit a number of times as determined by baffles in the heads.

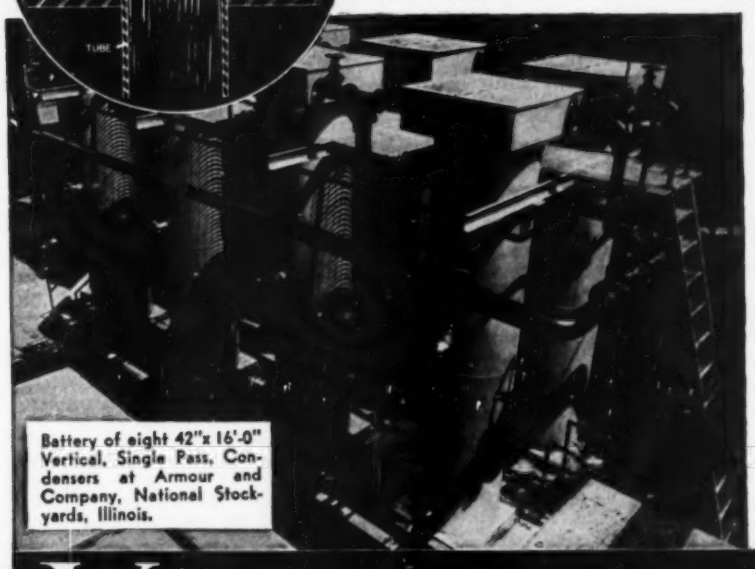


375 tons capacity Multi-pass Condenser installation at Railways Ice Co., Belen, New Mexico.



Vertical Single Pass Condensers
(Film Type)

Patented ferrules give equal distribution of water to and over the surfaces of all tubes in a unit.



Battery of eight 42"x 16'-0" Vertical, Single Pass, Condensers at Armour and Company, National Stockyards, Illinois.

HORIZONTAL and VERTICAL TYPES SHELL and TUBE CONDENSERS For Every Service

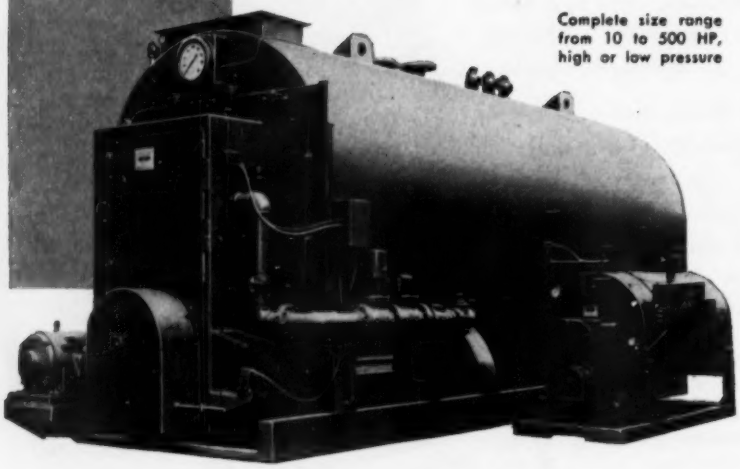
Write For Bulletin RC-1

HENRY VOGT MACHINE COMPANY
INCORPORATED
1000 W. ORMSBY ST., LOUISVILLE 10, KY., U.S.A.
Branch Offices: NEW YORK, CHICAGO, CLEVELAND, DALLAS, PHILADELPHIA, ST. LOUIS, CHARLESTON, W. VA.

Vogt REFRIGERATION CONDENSERS

you save three ways on steam with Continental AUTOMATIC BOILERS

3 . . . installation, fuel and maintenance!



Complete size range from 10 to 500 HP, high or low pressure

You save on the installation of Continental Automatic Boilers . . . Factory assembled and shop-fire tested, they are ready to operate after simple service connections in your plant. No special stack or foundation required.

You save on fuel with Continental Automatic Boilers . . . An exclusive firing method—U.S. and foreign patents pending—controls the mixture of fuel and air for uniform flame of high radiancy, giving a high heat transfer at a *guaranteed* efficiency of 80% plus! Built-in steam separator of special design assures steam 99% dry! Heat generated by the fuel—heavy or light oil, gas or a combination—is transferred *direct* to the boiler water, instead of being wasted in heating a refractory firebox.

You save on maintenance with Continental Automatic Boilers . . . No baffles or refractory to replace or repair. This means front and back covers can be opened to provide quick, easy access to furnace and tubes.

Continental Automatic Boilers are of rugged, built-to-last construction and improved precision design gained by 40 years of practical boiler building. Hundreds of these highly efficient boilers are setting records in economical, dependable and trouble-free service throughout the U.S. and Canada.

Why not find out how Continental can save you money on steam? Call or write today for full information.

BE BOILER ENGINEERING
AND SUPPLY COMPANY, INC.
1 Manavon Street • Phoenixville, Pa.
40 Years of Boiler Experience

Readers' guide to advertised products

(Continued from page 112)

Grommet V-Belts **529**
Coupon on p 103 offers set of reports telling users' experience and showing actual installations of grommet belts. The B. F. Goodrich Co.

PACKAGED STEAM GENERATORS

Superior Steam Generators **530**
Catalog 502 contains complete details on Superior packaged steam generators. Superior Combustion Industries Inc. p 141.

Packaged Steam Boilers **531**
Catalog fully illustrates and describes Cleaver-Brooks steam boilers. Cleaver-Brooks Co. p 43.

Amesteam Generator **532**
Free bulletin contains data on the Amesteam generator. Ames Iron Works. p 118.

Packaged Automatic Boilers
Information available on Continental packaged automatic boilers. Boiler Engineering & Supply Co. p 114.

PACKING AND GASKETS

Packings **534**
6-page guide, "Johns-Manville Packings for the Power Plant" available. Johns-Manville Corp. p 104.

Packings **535**
Catalog contains complete information on R/M packings. Raybestos-Manhattan, Inc., Packing Div. p 34.

Gaskets
Adv. p 112 contains data on Ajax spiral wound gaskets. United States Gasket Co.

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Insert "key" numbers on return post card found on page 107. For quick reference to free literature offered by advertisers in this issue, refer to listing on page 118. Our Reader's Service Department will handle your request promptly.

PIPE, TUBING & HOSE

Pipe Hangers **536**
Catalog contains data on adjustable pipe hangers and supports for every piping requirement. Grinnell Co., Inc. p 37.

Wrought Iron Pipe **537**
Available bulletin "The ABC's of Wrought Iron" with complete data. A. M. Byers Co. p 31.

Industrial Hose
Adv. p 40 contains data on hose for any industrial need. New York Belting & Packing Co.

Flexible Metal Hose **537**
Cat 500 contains data on seamless and interlocking hose in bronze, steel, and stainless steel. Atlantic Metal Hose Co. p 117.

Insulated Piping
Adv. p 130 contains data on Ric-wiL prefabricated insulated piping. The Ric-wiL Co.

Piping Layouts **539**
Piping Layout No. 64 contains detailed information. Jenkins Bros. p 9.

Expansion Joints
Adv. p 62 contains information on gunpakt expansion joints. Yarnall-Waring Co.

PUMPS

Controlled Volume Pumps **540**

Information available on Milton Roy controlled volume pumps for boiler water treatment. Milton Roy Co. p 45.

Pumps **541**

Bulletin LG contains data on complete line of IMO pumps. DeLaval Steam Turbine Co. p 4.

Pumps

Adv. p 61 contains data on DMV and DHV line of I-R pumps. Ingersoll-Rand Co.

REFRACTORY CONCRETES

Refractory Concrete **542**

Information available on Lumnite for refractory concretes. Lumnite Div., Universal Atlas Cement Co. p 44.

Insulating Cement **543**

Coupon on p 136 offers catalog, prices and free sample of Stic-Tite insulating cement. Refractory & Insulation Corp.

Refractories

Adv. p 33 gives information on Kaocast refractories. Babcock & Wilcox Co., Refractories Div.

SOOT BLOWERS AND TUBE CLEANERS

Tube Expanders

See adv. p 140 for information on triple-purpose tube expanders. The Gustav Wiedeke Co.

Tube Cleaners & Expanders **544**

Full details on Airetool tube cleaners and expanders. Airetool Mfg. Co. p 130.

STEAM SPECIALTIES

Steam Traps **545**

44-page steam trap book contains complete data on Armstrong trap design and operation. Armstrong Machine Works. p 2.

Steam Traps **546**

Adv. p 131 offers catalogs: traps—600; separators—500; boiler trim—700. Wright-Austin Co.

Traps **547**

Catalog 751 (or see Sweet's) tells all about freeze-proof steam traps. W. H. Nicholson & Co. p 132.

TOOLS

Concrete Drill Bit **548**

Literature and prices available on RCD concrete drill bit. Rotary Concrete Drill Co. p 117.

Pipe Tools **549**

Catalog contains complete data on Toledo pipe tools and power pipe threading machines. The Toledo Pipe Threading Machine Co. p 124.

Proto Tools **550**

Send 10c for 68-page catalog of Proto tools. Plomb Tool Company. p 6.

Snap-On Tools **551**

Industrial and general catalog of 4,000 hand and bench tools. Snap-On Tools Corp. p 135.

TRANSFORMERS

Transformers

Adv. p 126 contains information on Acme stepdown transformers. Acme Electric Co.

TURBINES

Turbines **552**

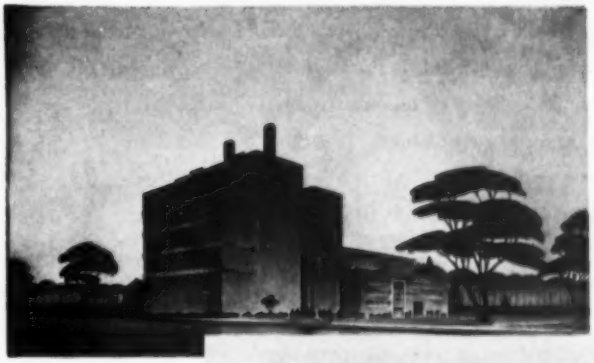
Bull 135 contains data on Coppus turbines from 150 hp to smallest size. Coppus Engineering Corp. p 25.

(Continued on page 116)

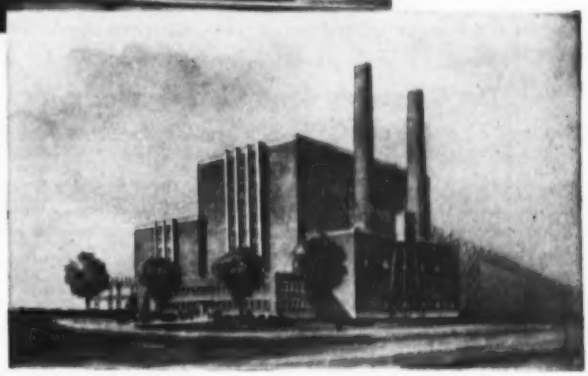
ON THESE TWO INSTALLATIONS

the AEROTEC SERIES

Assures 97.5% FLY ASH COLLECTION Efficiency



LEFT: The 264,000 kw (four units) J. Clark Keith Generating Station of The Hydro-Electric Power Commission of Ontario at Windsor, Canada. H. G. Acres & Co., Niagara Falls, Ontario, Consulting Engineers.

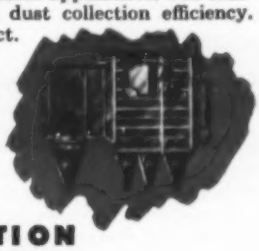


RIGHT: The 400,000 kw (four units) Richard L. Hearn Generating Station of The Hydro-Electric Power Commission of Ontario at Toronto, Canada. Stone & Webster Engineering Corp., Boston, Mass., Engineers and Constructors.

Here's on-the-job proof that Aerotec Series Mechanical-Electrical Dust Collectors are used for continuous efficiency. Guaranteed 97.5%, at normal full load the overall efficiency is anticipated as high as 99% at these two Canadian generating stations of The Hydro-Electric Power Commission of Ontario. Aerotec Series Collectors serving each plant combine a design 3RAS Mechanical and an Electrical Precipitator.

In the Mechanical unit, small diameter, permanent molded aluminum tubes provide high efficiency. Exclusive Aerotec pocket type collecting electrodes in the Electrical Precipitator reduce reentrainment of dust in the gas stream, contributing to a sharp improvement in stack appearance. The combined actions of these units assure maximum dust collection efficiency. Many Aerotec Series installations verify that fact.

Your plant can eliminate dust nuisances with Aerotec equipment just as many well-known companies have done. This highly successful performance is a reliable measure of Aerotec ability to solve your dust collection problems. Write our Project Engineers today!



Project Engineers

THE THERMIX CORPORATION

GREENWICH, CONNECTICUT

(Offices in 38 Principal Cities)

Canadian Affiliates: T. C. CHOWN, LTD.

Montreal 25, Quebec — Toronto 5, Ontario

THE AEROTEC CORPORATION

GREENWICH, CONN.

Niagara's HYGROL DRIES AIR BEST

with exact moisture content

- to control your product's quality
- to prevent condensation on your product or material
- to prevent changes due to moist air in contact with your product
- to protect your material from dampness
- to protect your processing of moisture-sensitive material
- to DRY your material or product
- to pack or store your product safe from moisture damage
- to get exact moisture control for the precise atmosphere condition you need
- to provide precise atmospheric conditions for testing
- to increase your air conditioning capacity
- to DRY large quantities of fresh air from outdoors

The Niagara's Controlled Humidity Method using HYGROL moisture-absorbent liquid is

Best and most effective because . . . it removes moisture as a separate function from cooling or heating and so gives a precise result constantly and always. Niagara machines using liquid contact means of drying air have given over 20 years of service.

Most reliable because . . . the absorbent is continuously reconcentrated automatically. No moisture-sensitive instruments are required to control your conditions.

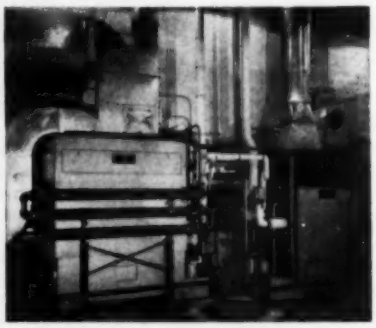
Most flexible because . . . you can obtain any condition at will and hold it as long as you wish in either continuous production, testing or storage.

Easiest to take care of because . . . the apparatus is simple, parts are accessible, controls are trustworthy.

Most compact, taking less space for installation.

Inexpensive to operate because . . . no re-heat is needed to obtain the relative humidity you wish in normal temperature ranges and frequently no refrigeration is used to remove moisture.

The cleanest because . . . no solids, salts or solutions of solids are used and there are no corrosive or reactive substances.



Niagara Controlled Humidity Air Conditioning

This method removes moisture from air by contact with a liquid in a small spray chamber. The liquid spray contact temperature and the absorbent concentration, factors that are easily and positively controlled, determine exactly the amount of moisture remaining in the leaving air. Heating or cooling is done as a separate function.

For complete information write

NIAGARA BLOWER COMPANY

Dept. IP, 405 Lexington Ave., New York 17, N. Y.

District Engineers in Principal Cities of United States and Canada

Readers' guide to advertised products

(Continued from page 115)

Steam Turbine Generators

Adv. p 53 contains data on Worthington steam turbine generators. Worthington Corp., Steam Turbine Div.

Turbines **553**

Bull S-116 describes Terry solid-wheel turbine. Bull S-146 describes multistage turbines. The Terry Steam Turbine Co. p. 40.

VALVES

Pump Valves **554**

Catalog gives 4 ways to cut pump repairs. Sims Pump Valve Co. p 117.

Butterfly Valves **556**

Valve catalog contains data on Rockwell butterfly valves. W. S. Rockwell Co. p 140.

Gate Valves **557**

Bulletin describes Darling revolving Disc gate valves. Darling Valve & Mfg. Co. p 42.

Blow-Off Valves **558**

Cat 12-D completely describes Edward blow-off valves. Edward Valves, Inc. p 22, 23.

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Valves

Adv. p 7 contains information on Crane valves. Crane Co.

Gate Valves **559**

Cat No. 10 describes Chapman List 960 forged steel gate valves. The Chapman Valve Mfg. Co. p 50.

WATER TREATMENT

Return Line Corrosion **560**

Tech. Bull 124 describes Betz filming amine treatment. W. H. & L. D. Betz. p 17.

Water Conditioning

Adv. p 52 contains data on Worthington water softening systems. Worthington Corp., Water Treating Div.

Water Treatment **561**

Further details available on Nalco water treatment security. National Aluminate Corp. p 13.

Water Treatment Plants **562**

Bulletins available on manual and automatic water treatment plants. Hungerford & Terry, Inc. p 139.

Water Conditioning **563**

Free copy of "Trends in Application of Deaerating Heaters for Treatment of Boiler Feedwater". Graver Water Conditioning Co. p 32.

Water Treatment **564**

Free data sheet available on Bird-Archer's Concentrol Anti-foam. Bird-Archer Co. p 60.

Industrial Water Treatment **565**

Coupon on page 111 offers bulletins on Dearborn polyamide Anti-Foams and industrial water treatment. Dearborn Chemical Co.

DRILL CONCRETE

EASIER! FASTER! BETTER!

RCD Drill Bit for use with rotary electric or air drills

Drills perfect, precision holes even in *reinforced* concrete. Super fast and easy (6" deep hole in 1 minute!) Pays for itself in time-savings. Made to last.

Widely used for the past five years by most of the largest U. S. corporations, manufacturers, and utilities, as well as thousands of smaller firms, installation men, contractors, electricians, plumbers, etc. Superior concrete drilling **plus longer drill bit life due to FREE factory re-sharpening service** keeps them sold.

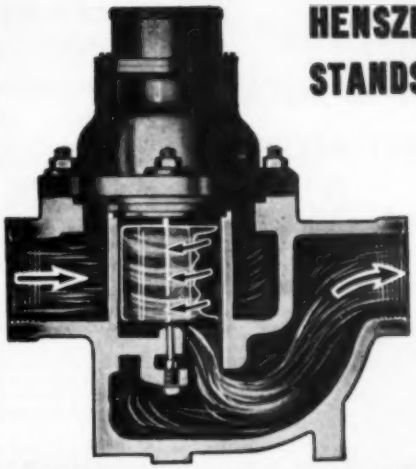
Personalized guarantee given to every RCD Drill Bit user

If dealer cannot supply (or service), buy direct.

Send for illustrated literature and price list

ROTARY CONCRETE DRILL CO.

650 S. Arroyo Parkway, Pasadena 1, Calif.



HENSZEY *Feed Water* METER STANDS UP *where others* FAIL

The cutting, abrasive action of hot, dirty Boiler Blowdown quickly breaks down meters that depend upon close clearances and intricate parts for their accuracy. Henszey Meters stay accurate—stay on the job—accurately measuring Boiler Blowdown, Feed Water, Condensate, Free-Running Chemicals and other "hard-to-measure" liquids. For details consult Sweet's Catalog or write:

HENSZEY CO., Dept. A-1, WATERTOWN, WISCONSIN

HENSZEY

FEED WATER METERS

Continuous Blowdown • Distillation Systems • Heat Exchangers
Boiler Feed Regulators • Flow Indicators • Proportioning Valves
also MILK EVAPORATORS and PRE-HEATERS

HOW YOU CAN MAKE PUMP REPAIRS EASIER

Worn seats and valve discs, broken springs and stems are eliminated with Sims Pump Valves. Sims valves cure frequent pump repair headaches with exclusive design features. They're **guaranteed** to give you better pump performance.

You get longer service from seats and discs because of rotating disc that changes to a new seating-surface every time it opens. Valves can't hammer up and down.

Inclined rib seat and shock-absorber stem heads combine to permit increased speed without valve-knock. Capacity can be increased 40% and more.

Low resistance through seat reduces turbulence — gives protection against vapor binding.

Long guide gives even lift — reduces wear. Spring is protected against jamming.

Write for new catalog showing how Sims valves fit your pump and give better pump performance.

SIMS PUMP VALVE CO., INC.

145 HUDSON ST., NEW YORK 13, N. Y. • M & M BLDG., HOUSTON, TEXAS

Atlantic Flexible Metal Hose Offers

FREEDOM FROM BREAKDOWNS

due to VIBRATION, MISALIGNMENT, EXPANSION, CONTRACTION.

—and is better for conveying steam, gases, molten chemicals, oils, refrigerants, tars, asphalt, alkalies, gasoline, light or semi-solids. Seamless or Interlocking construction in steel, stainless steel, bronze, ⅛"—36" I.D. with appropriate fittings.

Write for Bulletin 500. See our Catalogs in Sweet's Files for Product Designers and Mechanical Industries.

Atlantic Metal Hose Co., Inc.

124 W. 64th St., New York 23, N. Y.

20 SIZES...
10 to 600 h.p...
15 to 200# OIL OR GAS

AMESTEAM GENERATOR

This automatically controlled packaged boiler unit includes:

★ all piping and wiring, ready for your service connections.

★ fan, feed water pump, condensate tank, injector, blow-off valve, necessary refractories, insulation and metal jacket.

ALL YOU NEED is fuel tank, gas vent and service connections.

—AND YOU KEEP RIGHT ON SAVING with these trouble-free, fully automatic units with their eye-level controls, their accessibility inside and out, and fuel-saving 80% guaranteed efficiency!

FOR FACTS ON LOWER COST STEAM WRITE FOR THIS FREE BULLETIN NOW!

NAME.....

COMPANY.....

ADDRESS.....

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AMES IRON WORKS

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Builders of Better Boilers Since 1848

QUICK REFERENCE TO BULLETINS & CATALOGS OFFERED BY ADVERTISERS IN THIS ISSUE

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ACCURACY

of Regulation.....

Just as the champion bowler maintains *top* control when he chalks up a "strike", the Leslie team wraps up perfect performance in LESLIE Temperature Regulators.

There's a LESLIE Regulator for every temperature control problem—designed to meet the demand for accurate, reliable, constant temperature regulation.

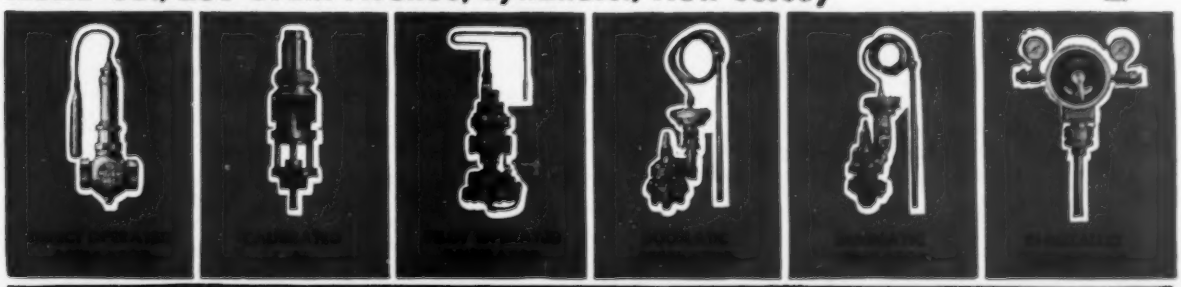
It will pay to explore the advantages of—

TRADE LESLIE MARK

- **Single Seated Construction**
- **Calibrated Dial Adjustment**
- **Duomatic Control**
- **Liquid Filled Elements**
- **Other Leslie Features**

All described in Bulletin 464, available on request.

LESLIE CO., 263 Grant Avenue, Lyndhurst, New Jersey



QUALITY REGULATORS FOR OVER HALF A CENTURY

Spot news

Short, "boiled-down" paragraphs on the most interesting recent events and developments in American industrial plants

Plastic Pipe Is Installed as Underground Conduit for Power Lines

In a test project undertaken by Kingsport Utilities, Kingsport, Tenn., extruded Tenite plastic pipe was used for the first time as underground conduit for power lines. The trial installation, in cooperation with Tennessee Eastman Co., was made in a city block where the power company has put in a 5-light White Way. Characteristics of plastic pipe, such as flexibility, ease of installation, corrosion resistance, high impact strength and light weight, are reported as reasons for the experiment.

Plastic pipe in 20 ft lengths was used instead of the regular 5 ft sections of asbestos and cement type conduit. Due to the pipe's flexibility, the trenches did not require the straight sides and base needed for the usual rigid type of conduit. Joining was a speedy job, too. Before slipping together, a thinner was used to soften the section ends, followed by a coat of special cement. After 30 min drying, the joints were strong as the pipe itself.

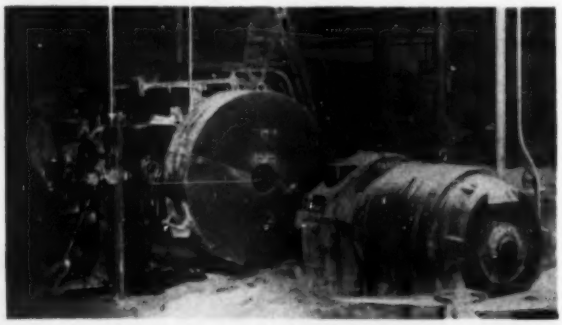
It required 20 min for two men to lay 247 of the 1100 ft of pipe. By comparison, it was stated that it would have taken 4 hr to lay the regular rigid conduit. While tamping the backfill, it also was observed that the plastic pipe did not break when struck by a tamping bar, as so often happens with conduit types normally used.

Crown Products Picks Motors To Match Jobs

Motors featuring a wide variety of mechanical constructions and electrical characteristics are offered as standard equipment by manufacturers. Specifying the best motor to perform a particular job therefore requires more than merely knowing the horsepower required. A good example of effective engineering in the selection of motors is provided by Crown Products Co., a manufacturer of rubber products.

At its plant in Ralston, Neb., Crown uses 170 motors totaling 1300 hp, and ranging from ⅛ to 300 hp. Equipment, ranging from standard machinery for the rubber industry to special process equipment designed and built by the company, presents a wide variety of power requirements.

In selecting motors, the company sought to standardize, wherever possible, on a type and make best suited to general operating conditions. Since considerable water is used,



To drive this 60 in. rubber mill, requiring constant speed, engineers specified a 125 hp synchronous motor

and talcum powder is found everywhere to keep the rubber from sticking, most of the units selected are of drip-proof design, manufactured by Fairbanks, Morse & Co. All have ball bearings sealed in cartridge type housings which require lubrication once a year. Because of a heavy operating schedule, heavy-duty units also were desirable.

(Continued on page 122)

The Cover—Natural Gas

Texas Eastern's 24 in. pipeline, the famous "Big Inch", originates near Longview, Texas and extends 1254 miles to Phoenixville, Pa., where it reduces to a 20 in. line leading to its terminal point at Linden, N. J.

Along the way are numerous stations that were installed to provide booster pressure for transporting the natural gas to its destination. Included at these stations is the equipment necessary to clean and cool the gases as they are compressed. Here are a group of vertical gas scrubbers at Station G, near Fordyce, Ark.

Acknowledgment is made to the Texas Eastern Transmission Corp. for permission to reproduce this months cover from "The Inch".

In Plant After Plant—

One of America's Largest Auto Manufacturers Has Selected MULTICLONES for Fly Ash Recovery!

Over 35 MULTICLONE Units To Date in Various Plant Divisions!

YEAR AFTER YEAR—in plant after plant—one of the nation's largest automobile manufacturers has selected Multiclone Collectors for recovering fly ash and dust in its many manufacturing divisions. This repeated selection of Multiclones—now totalling over 35 units—is high testimony to the many vital advantages found in Multiclone equipment. Check over some of these advantages as outlined at left . . . advantages that will save space—cut installation costs—boost recovery efficiencies—minimize maintenance and make other important savings on *your* recovery operations, too.

Then consider this fact . . . Any *one* of these advantages is sufficiently important in itself to make Multiclone equipment the logical choice for your recovery operations. But when you realize that the Multiclone offers definite, clear-cut advantages on *every* qualification essential to maximum efficiency and economy in recovery operations you have some idea of the far-reaching savings you will make by installing Multiclone.

Let us give you further information on Multiclone recovery equipment. A letter, wire or phone call to our nearest office places the information in your hands without obligation. Get *all* the facts—and you'll get Multiclone!

A Few of *Many* MULTICLONE Advantages!

POINT 1 —It Saves Space!

Plant space costs money. Because the Multiclone makes *really important* savings in space, it makes similar savings in plant costs. The chart tells only part of the story because, in addition to being far more compact both in square and cubic footage, the shape of the Multiclone can be adjusted to fit various space requirements—either long and narrow, short and wide, or square. You can often fit the Multiclone into tight spaces or waste areas too small for other equipment!

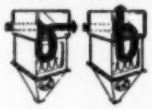
Make	Relative Space Requirements In Sq. Ft.	In Cu. Ft.
Multiclone	1.0	1.0
Collector A	2.1	1.8
Collector B	5.9	3.2
Collector C	6.8	3.9

POINT 2 —It Recovers the "Fines"!

Because its exclusive vane design and small diameter tubes generate higher centrifugal forces, the Multiclone recovers a large percentage of even the very fine particles 10 microns and less as well as the heavier particles. Multiclone's high recovery of both small and large particles means high overall collecting efficiency.

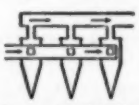
POINT 3 —It is Unusually Adaptable!

In addition to the shape adaptability outlined above, Multiclone's inlet-outlet connections are also readily adaptable to plant restrictions. Where headroom is low, install the Multiclone with side-inlet, side-outlet. Where side clearances are small, use side-inlet, top-outlet arrangement. Or still other arrangements are possible!

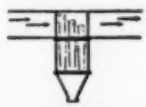


POINT 4 —It is Simple!

Both installation and maintenance of the Multiclone are unusually simple. For example, the Multiclone requires only a *single* inlet and a *single* outlet duct compared with the complicated multiple ducts of conventional cyclones. This not only saves space—but is simpler and cheaper to install and insulate. Moreover, the Multiclone has no filters to replace, no high-speed moving parts to maintain, nothing to require frequent cleaning or repair . . . and a *single* collecting hopper serves *many* tubes!



Conventional Cyclone



Multiclone

POINT 5 —Still Other Advantages!

The above advantages are by no means the complete story on Multiclone savings. Get all the facts before you decide on any recovery installation.

Send for this Multiclone booklet!

COTTRELL PRECIPITATORS · MULTICLONE COLLECTORS · TURBULAIRE SPRAY DRYERS

WESTERN Precipitation CORPORATION

ENGINEERS, DESIGNERS & MANUFACTURERS OF EQUIPMENT FOR COLLECTION OF SUSPENDED MATERIALS FROM GASES & LIQUIDS

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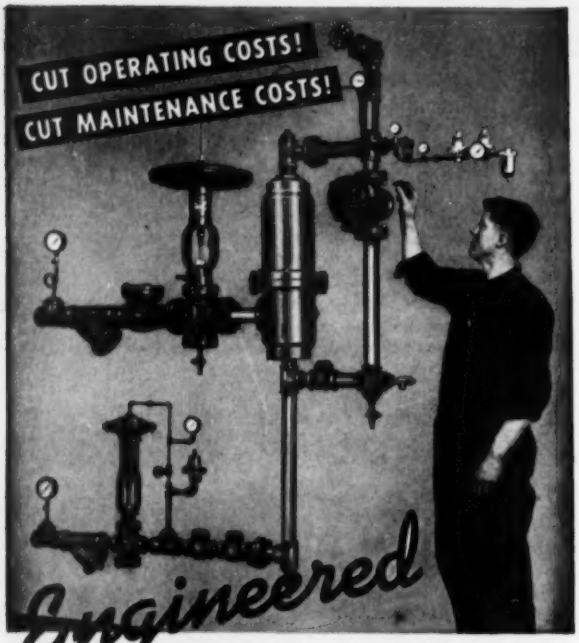
PRECIPITATION CO. OF CANADA, LTD., DOMINION SQ. BLDG., MONTREAL

THE SURE WAY TO
CUT HOT WATER
Costs!

Pick INSTANTANEOUS WATER HEATERS



TO PROVIDE
ANY VOLUME OF WATER
AT THE TEMPERATURE REQUIRED!

Here's the money-saving answer to hot water required for industrial needs. PICK Heaters provide hot water *instantly* — by steam injection. They're entirely automatic to provide and accurately maintain temperatures up to 180° F. The exclusive Pressurizer Piston stabilizes injection pressure — eliminates pipe hammering and shaking. Available in seven sizes with rated capacities of 10 to 200 gallons per minute. Greater volumes can be obtained by multiple installations. Installation is simple, requiring only ordinary pipe connections.

NO STORAGE TANKS NEEDED
Compact design permits installation in corners, on walls or overhead.

EASILY CLEANED
No coils. Can be cleaned in a matter of minutes — without dismantling.

Proved
BY PERFORMANCE IN
FACTORIES • HOSPITALS
LAUNDRIES • BREWERIES
DAIRIES • TANNERIES
CANNERIES

For Engineering Details and Specifications, Write Dept. IP-1

MANUFACTURED BY
PICK MANUFACTURING CO.
WEST BEND, WISCONSIN, U.S.A.

Spot news

(Continued from page 120)

Having standardized on some of the general characteristics, Crown concentrated on the specific power requirements of each machine. First step in producing rubber is the blending of ingredients in a large mixer. A two-speed, squirrel cage induction motor was selected. Although normally operated at 450 rpm and 150 hp, it can be increased to 900 rpm at 300 hp to step up production. This constant-torque motor can be started across the line at full voltage with comparatively low starting current.

Every 3 to 5 minutes, the mixer dumps a batch of material into a rubber mill. Here, the requirement is constant speed with no variation or slippage. A synchronous motor was selected, since it is unaffected by sharp variations in load. Synchronous motors also were used, whenever possible, to improve power factor.

In another instance, a tuber is used to extrude such products as hose and gasket stock. Speed of the unit must be varied with changes of product size and viscosity of the material. To provide flexibility of speed control, Crown selected a 30 hp d-c motor with speeds from 400 to 1200 rpm in 20 intermediate steps.

In designing a special machine to make fan belts, serious space limitations were encountered. An axial air gap motor occupying about a third the space of conventional types was chosen. In still another instance, an explosion-proof motor was called for because of hazardous fumes.

From Crown's point of view, the most important consideration in motor operation is dependability and continuity of service. Since motor failure, in many cases, causes rubber to freeze in the machines, success of the company's motor policy is best measured by the fact that the plant has experienced only one motor failure, and that occurred more than nine years ago.

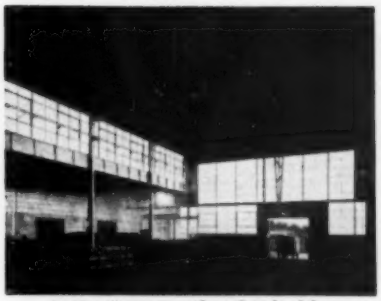
—*End*

TRANSFORMERS ARE DESIGNED FOR LOW NOISE LEVEL

Dry-type transformers in two power centers at Massachusetts Institute of Technology were specially designed by Westinghouse Electric Corp. to operate quietly. By using more iron in the cores, thus reducing flux density, sound level of both units was reduced to 60 db. Units are rated 1000 kva at 13.8 kv and 200 kva at 2.4 kv

Is your heating problem here?

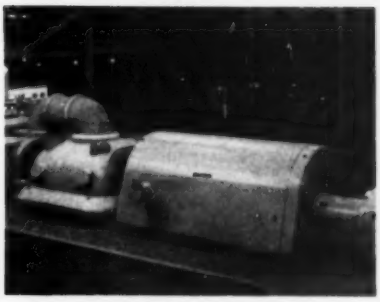
Negative pressure resulting from exhaust fans, sucks in cold air.



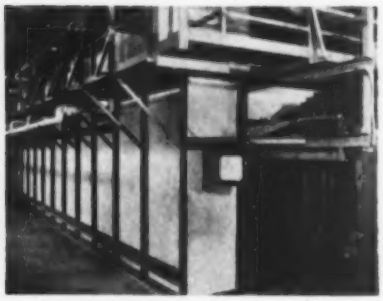
Drafty doorways that let in big blasts of cold air.

High ceilings that waste large volumes of rising heat.

Cold windows that pour chilling drafts down on the floor.



Large areas that consume excessive amounts of heat.



Processing needs that require high temperatures.

There's a Trane unit heater here to solve it!

Ventilating Heater

Roof hood, with heating section optional, provides make-upair; solves negative pressure problems.

Model H Unit Heater

. . . with exclusive *louver fin* diffuser, puts heat *where* it's needed, *whenever* it's needed.

Force-Flo Heater

. . gives you a large volume of heated air from a handsome compact unit.

Torridor

. . . blower-type, delivers large volumes of heated air long distances, with or without ducts.

Projection Heater

. . . with exclusive *louver cone* diffuser, projects ceiling heat to floor accurately, powerfully.

Gas-Fired Unit Heater

. . . rugged, built like a boiler. Brings you new efficiency and economy in gas-fired heating.

To get the right kind of heat—choose from the line that's most complete

You'll find that these six TRANE Unit Heaters, together with the two exclusive diffusers, give you the *one right* combination for *any* unit heater application.

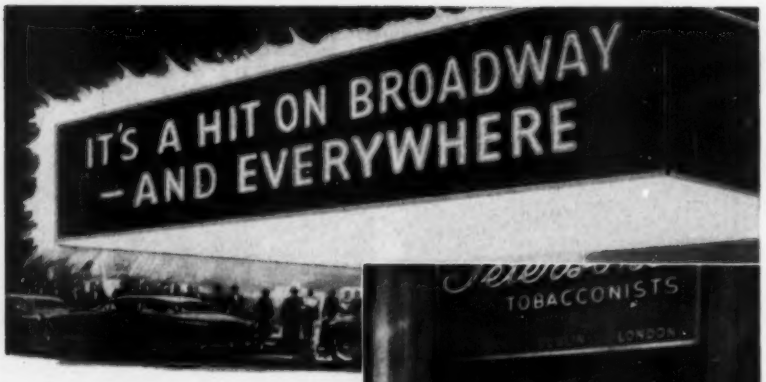
And that's the secret of efficient, economical heat—getting the *right* heater for the job.

See your nearest TRANE sales engineer, or write TRANE, La Crosse, Wis.

TRANE unit heaters

The Trane Company, La Crosse, Wis. • Eastern Manufacturing Division, Scranton, Pennsylvania
Trane Company of Canada, Limited, Toronto, Ontario • 80 United States and 14 Canadian Offices

MANUFACTURING ENGINEERS OF AIR CONDITIONING, HEATING AND VENTILATING EQUIPMENT



TOLEDO
THREADERS AND POWER DRIVES

Gear Up Production!

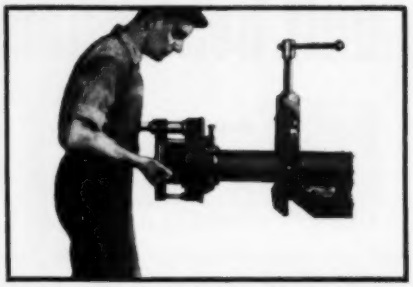
Sure enough—the street scene at right is really Broadway, N.Y.—where the mechanic is operating a Toledo Power Drive and No. 2 Geared Threader. This job of installing new 3" red brass for water service from the city main was handled by Water and Sewer Service Co.

Time was important on this job—as a trench was dug in the street and traffic had to detour.

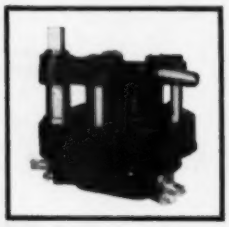
Time was saved by high-speed performance of the Toledo Power Drive operating Toledo geared tools! This also means *labor-saved* . . . and *money saved* for the contractor!

Wherever the job—in shop, plant or in the field—you can *speed up* pipe fitting and *reduce costs* with Toledo Tools! Precision-built . . . dependable. Order through your supply house. Write for catalog. The Toledo Pipe Threading Machine Co., Toledo, Ohio. New York Office: 165 Broadway, Room 1310.

Toledo Power Drive operating a Toledo No. 2 Geared Threader on 3" red brass for water service at 217 Broadway, New York City.



No. 2 geared adjustable threader, 2½" to 4" pipe, incl. *Lighter weight* than any other tool of this capacity!



No. 2BR Geared Adjustable, Threader, 2½" to 4" pipe, incl. New type 3-jaw pipe holder.

RELY ON THE 50 YEAR LEADER

TOLEDO PIPE TOOLS...
POWER DRIVES . . . POWER PIPE MACHINES

News
of men and companies

Allis-Chalmers Manufacturing Co.—Establishment of a new Akron branch of the Cleveland district office of the general machinery div under the management of Fred C. Timberman is announced. The new office is located in the First National Tower in Akron.

Allis-Chalmers Manufacturing Co.—A. Talbert is named an application engineer in the water conditioning section. R. L. Baseley and D. Sleeman are newly named to the substation and control sales sections, respectively.

American Leather Belting Association—Elected the following officers to serve for the year 1953: President, P. G. Rhoads, partner, J. E. Rhoads & Sons; Vice-President, Wm. F. MacDonald, president, E. F. Houghton & Co.; Treasurer, A. H. Rahmann, president, George Rahmann & Co.; Executive Vice-President and Secretary, E. R. Rath.

American Society of Mechanical Engineers—The election of F. S. Blackall, Jr., president and treasurer of the Taft-Peirce Manufacturing Co., as president of the society is announced. The election of four regional vice presidents and two directors-at-large was also announced. The regional vice presidents elected are H. R. Kessler, mgr, Republic Flow Meters Co.; P. R. Yopp, district sales mgr, The Babcock & Wilcox Co.; B. G. Elliott, professor of mechanical engineering, University of Wisconsin; and H. R. Pearson, personnel director, Dallas Power and Light Co.

Bigelow-Liptak Corp.—H. A. Janke, formerly chief draftsman is promoted to field service engineer. Other appointments include R. W. Jones as asst chief engineer, M. R. Huntton as chief draftsman and C. E. Wrobel as asst chief draftsman.

BullDog Electric Products Co.—Promoted two sales executives: they are M. C. Nelson, promoted to associates regional mgr, and H. D. Ogden who succeeds Nelson as administrative asst to the sales mgr.

Cooper-Bessemer engineers R. Boyer (right) and J. Fulleman (left) discuss supercharging with Dr. Alfred Buchi

Chicago Pneumatic Tool Co.—At a recent board of directors meeting, G. J. Coffey, v-p, was elected president to succeed the late W. L. Lewis who died last June..

Clayton Manufacturing Co.—Appointment of H. M. Kirkby as sales promotion mgr of the Steam Generator Div. is announced. He will make his headquarters at the Chicago Branch, 638 No. Albany Ave.

Elliott Co.—J. E. Reilly joined the Industry Engineering Dept. This department maintains offices at 715 Frick Building, Pittsburgh, Pa.

Beckman Instruments, Inc.—Appoints T. Fletcher mgr, special products div. replacing the former manager, J. F. Bishop, who was recently made assistant genl mgr of the company.

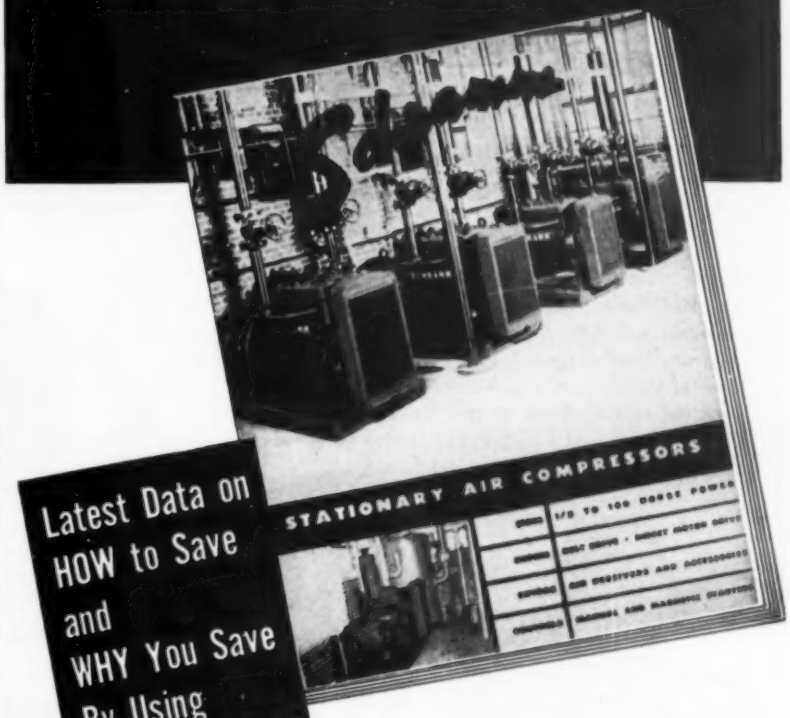
T. Fletcher V. Cioffi

Belco Industrial Equipment Div., Inc.—V. Cioffi is named sales mgr. New California offices are located at 4418 Vineland Avenue, North Hollywood. M. J. Sherry is in charge. J. Stoy, project engineer for the past three years, is named branch manager of the new Texas offices, located at 2009 Fannin Street, Houston. H. Kipp, formerly chief engineer with the American Water Softener Co., is appointed district mgr of the Philadelphia office located in the Commercial Trust Bldg.

National Association of Vertical Turbine Pump Manufacturers—The subject "Underground Water Sources, their conservation, protection and use" was the principal topic of discussion at the recent semi-annual meeting of the National Association of Vertical Turbine Pump Manufacturers. L. C. Kimball, sales mgr, Byron Jackson Co., and retiring president of the association, reported on the association's activities of the past year, and papers on topics of interest to the association and the pump industry were presented by W. C. Mumford, mgr, Vertical Turbine Pump Div., Worthington Corp., G. F. Twist, genl mgr, Peerless Pump Div., Food Machinery and Chemical Corp.; C. E. Wilson, honorary director of the association, T. E. Woodruff, mgr, Pump Dept, Fairbanks Morse & Co., and H. E. Carloss, v-p, Deming Co. Election of officers for the ensuing year was also held. The new officers are: president, G. F. Twist, Peerless Pump Div., Food Machinery and Chemical Corp.; vice-president, T. E. Woodruff, Fairbanks Morse & Co.; secretary, B. A. Tucker, Peerless Pump Div., Food Machinery and Chemical Corp.

(Continued on page 126)

NEW, VALUABLE BOOKLET ON STATIONARY AIR COMPRESSORS



Latest Data on HOW to Save and WHY You Save By Using SCHRAMM

16 color pages include:

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- Space-Saving Advantages
- Value of Unit System
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- Complete Schramm Installation with Schramm Accessories
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Extras

. . . in fact, the complete Schramm story on stationary air compressors.

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The Compressor People · WEST CHESTER · PENNA.

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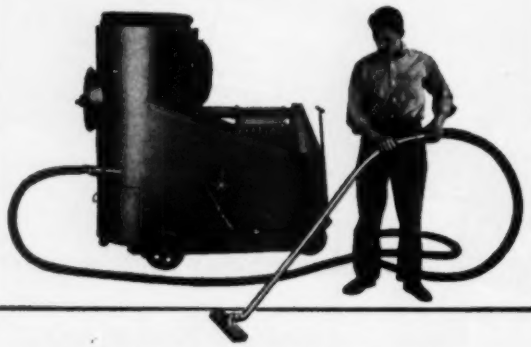
PROFIT by the EXPERIENCE of America's FINEST PLANTS

They REPEAT-ORDER
HOFFMAN *Heavy-Duty*
VACUUM CLEANING EQUIPMENT for Wider Range Dust Removal!

One installation sells another, as plant after plant finds that Hoffman vacuum cleaning units save labor—salvage material—reduce product defects—eliminate dust hazards. They've proved that they can clean larger areas of walls, floors and overhead surface with Hoffman equipment. Built to provide bigger capacity, higher vacuum and long years of service on the most grueling plant cleaning jobs.



YOUR CHOICE OF 4 BIG-CAPACITY PORTABLES

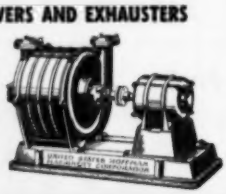
Advanced design and construction features for fast, efficient cleaning, with one-man handling. 1½, 3, 5, and 7½ H.P. models to match your specific cleaning requirements

STATIONARY SYSTEMS IN A WIDE RANGE OF SIZES TO FIT YOUR MAINTENANCE OR PRODUCTION OPERATIONS

Provides cleaning in several areas at the same time. Sweepers attach cleaning hose to conveniently located inlets (in a permanently piped system). Dust is removed pneumatically to central collectors for easy disposal.

MULTISTAGE CENTRIFUGAL BLOWERS AND EXHAUSTERS

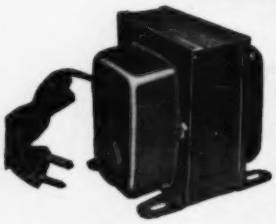
For agitation of liquids, combustion, mixing—for all air requirements (including the elimination of compressed air). No internal moving parts. Low power consumption. Adopted as standard in steel plants, textile and ice plants requiring 24-hour continuous service. Wide range of pressures, capacities and vacuum, for air or gas. Tell us your requirements.



AIR APPLIANCE DIVISION
U.S. HOFFMAN MACHINERY CORPORATION
300 EAST 13th STREET, NEW YORK 3, N.Y.
CANADIAN PLANT: CANADIAN HOFFMAN MACHINERY CO. LTD. NEWMARKET, ONT.

MAKE EVERY MACHINE INDEPENDENTLY LIGHTED WITH ACME ELECTRIC STEPDOWN TRANSFORMERS

• Acme Stepdown Transformers are available in standard ratings from 75 to 2000 watts. Ready for easy installations.

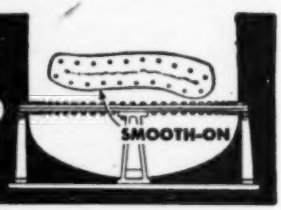


Motorized machines that are individually lighted (with a concentrated light at the working area) can be shifted in production lines with a minimum of expense and delay. An Acme Electric stepdown transformer mounted on the machine and connected to the power line can supply proper voltage for lighting requirements. Investigate this modern method of completely electrifying machinery.

ACME ELECTRIC CORPORATION
521 WATER ST. CUBA, N.Y.

Acme ACME Electric

To Repair A CRACKED CASTING



Smooth-On No. 1 Iron Cement, under a bolted patch plate, saved this large casting without the use of heat, when a long crack threatened to end its usefulness. This simple repair is typical of the countless uses that engineers, mechanics and maintenance men in industrial plants find for Smooth-On. They keep it handy for both emergency and routine maintenance repairs—stopping leaks, sealing cracks, tightening loose parts. If your supply house hasn't Smooth-On No. 1 in 1-, 5-, 20-lb. or larger size, write us.

FREE REPAIR HANDBOOK

Sealing cracks in apparatus and pipe lines is only one of the many time-saving, money-saving repairs this 40-page book will show you. 170 illustrations. Write today for YOUR free copy.

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Do it with SMOOTH-ON
THE IRON REPAIR CEMENT OF MANY USES

News
of men and companies

(Continued from page 125)

Food Machinery and Chemical Corp.—J. M. Hait, in charge of engineering, is elected to the board of directors and executive committee. He is head of the Central Engineering Dept.

J. M. Hait **A. M. Duty**

The Airetool Manufacturing Co.—A. M. Duty is named sales engineer in the Houston, Texas, branch office.

The B. F. Goodrich Co.—W. S. Richardson, v-p, is elected a director of the company and also to the position of executive v-p. He also was elected a member of the executive committee of the board of directors.

Link-Belt Co.—Announces appointment of H. J. McCormick as sales manager of the Caldwell plant, succeeding E. A. Wendell, currently on leave.

Nordberg Manufacturing Co.—Appointment of Huckabee, Inc., Sewickley, Penn. as marine and industrial distributor for Nordberg Type 4FS Diesel engines in western Pennsylvania and northern West Virginia is announced.

The Permutit Co.—Placed contracts for further extensions and improvements to the Birmingham, N. J., plant. They include a new laboratory and pilot plant building to cost approximately $200,000 in all.

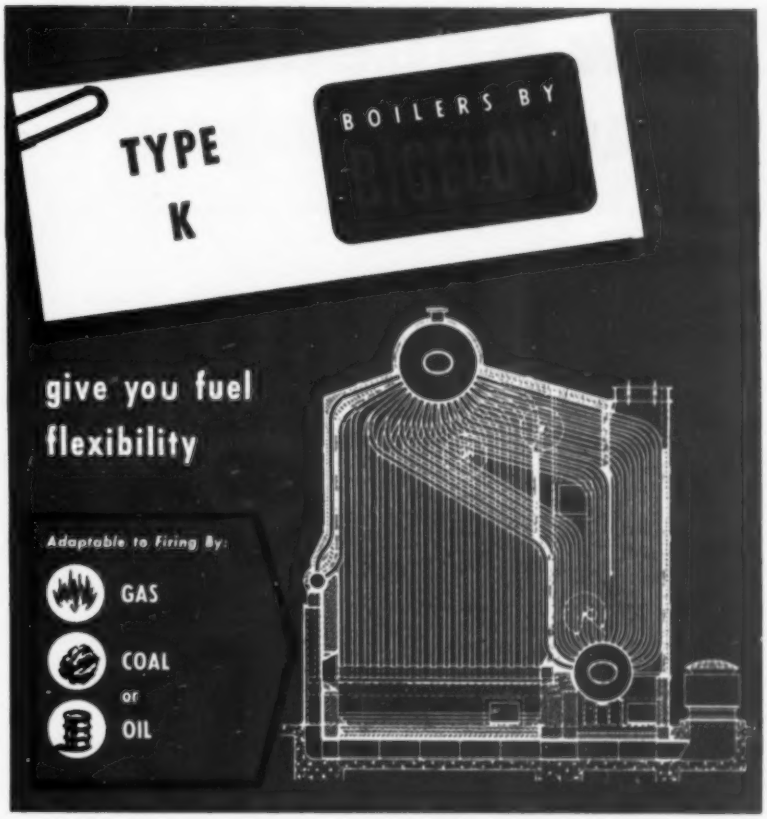
Meetings

JANUARY

American Institute of Electrical Engineers announces its winter general meeting to be held at the Hotel Statler, New York, Jan. 19-23.

Plant Maintenance Conference, sponsored jointly by the American Society of Mechanical Engineers and the Society for the Advancement of Management, will be held at the Public Auditorium, Cleveland, Jan. 19-22. The Plant Maintenance Show will be held concurrently with the meeting.

American Society of Heating and Ventilating Engineers will hold its 59th annual meeting at the Conrad Hilton Hotel, Chicago, Jan. 26-29.

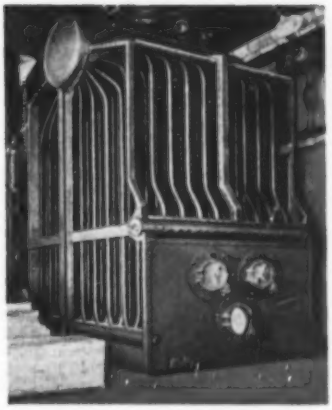


The construction facilitates conversion from oil to coal or coal to oil with minimum cost. The boiler design provides ample furnace volume for the various fuels.

Type KS Water-Tube Boilers By Bigelow are built in sizes ranging from 20,000 to 45,000 lbs. of steam per hr. Type KL Boiler sizes range from 35,000 to 70,000 lbs. of steam per hr. Type KV Boiler sizes range from 70,000 to 100,000 lbs. of steam per hr.

Compact—Low Maintenance—Low Fuel Cost.

Write for free catalog on the Types KS & KL or on any of the boilers listed below.



Bigelow Type KS-18 during erection at the E. & J. Gallo Winery, Modesto, Calif. Capacity 26,000 lbs. steam per hr., oil fired.

BOILERS BY BIGELOW

Water Tube Boilers—Bent Tube Types • Horizontal Return Tubular Boilers • Scotch Type Boilers • Two-Pass Boilers Electric Steam Generators

BI-5

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New bulletins and catalogs

Literature on engineering products and developments

Each new bulletin item has a key number for your convenience in asking for a free, personal copy. Insert key numbers on return post card found on page 107

AIR & DUST FILTERS & COLLECTORS

Foundry Dust Control **200**

Operation of a dust control system for foundries is described in 8-page bulletin 852. The booklet is in the form of a review of a 22-minute film, "The Invisible Shield," which shows a complete system in actual operation. The bulletin also tells how the film may be obtained for showings to interested engineering groups. Claude B. Schneible Co.

Electrostatic Precipitator **201**

"The Inside Story," a 4-page folder, describes the design features of electrostatic precipitators developed for sodium salt recovery in soda and sulphate pulp mills. Discussed are such topics as the construction of inlet and outlet flues, wet bottom design, electrical equipment and discharge electrodes. Research Corp.

COAL, ASH & BULK HANDLING

Bunker Seal **202**

"Stop Coal Dust!", 4-page folder 952, describes a zipper bunker seal designed primarily for use where coal is being distributed by belt conveyer and traveling tripper to an extended storage bunker. Illustrations and text describe how it works. Stephens-Adamson Mfg. Co.

Coal Chute **203**

Explained in 8-page bulletin 73 is the theory of how a conical coal chute prevents segregation. Actual installations are shown. Various accessories also are described. Stock Equipment Co.

General Catalog **204**

Products for use in the chemical processing industries are described in a new catalog. Among the items listed are protective coatings, tank and pipe linings, plastic fittings, hose, pinch valves, packings, conveyer belts and expansion joints. Chemical properties, temperature limitations, sizes and recommended working pressures also are covered. Mechanical Goods Div., United States Rubber Co.

COMPRESSORS

Air Compressors **206**

Descriptions, design features and specifications for industrial air compressors are contained in 16-page brochure 5110-A. Models are for belt or direct motor drive from ½ to 100 hp. Accessories and controls also are described. Schramm Inc.

Compressors **207**

Basic application data and design specifications for multi-stage, multi-cylinder compressors from 100 to 5000 hp are contained in 44-page engineering catalog M-70. Topics discussed include design features, lubricating system, bearings and counterweights, cylinders, motors and drives, automatic control, and typical installations. The Cooper-Bessemer Corp.

ELECTRICAL DISTRIBUTION

Enclosed Switch **208**

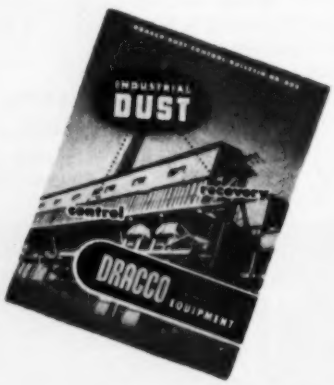
Construction features and advantages of a recently developed heavy duty metal enclosed switch, said to combine the functions of disconnect and load interrupter, are given in 4-page folder 5208. Units are for 600 v, a-c or d-c service. A table lists 2 and 3 pole models, with or without provisions for fuses, for 400 to 3000 amp ratings. Delta-Star Electric Co.

Circuit Breakers **209**

"What You Should Know About Circuit Breakers," 16-page manual 101, explains the operating principles of basic circuit breaker designs. Included are simplified diagrams of three basic types. Explanations, charts and diagrams deal with temperature factors, inrush current effects, tripping and reset time, quick and slow make-and-break, and wire deterioration rates. Heinemann Electric Co.

Dust Collection **205**

Five basic types of dust control equipment, designed to meet the needs of a wide variety of industries, are the subject of 40-page brochure 800. In addition to discussing features of design, construction and operation, the booklet also lists the advantages of each basic type, together with recommendations. Specifications are listed and actual installations are described and illustrated. Accessories such as fans, vibrators and valves also are presented. Technical information is presented to aid the engineer in solving dust collection problems. Of particular value is a table listing air volume and resistance at common velocities. Dracco Corp.



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ENGINES

Dual Fuel & Gas Engines **210**

Construction, operation and application features of 9 and 13 in. bore, 4 cycle, diesel dual fuel and spark-fired gas engines are contained in 12-page bulletin 205. Pressure lubrication, high velocity cooling, fuel systems and design characteristics are described. Ratings, weights, dimensions and standard equipment are tabulated. Nordberg Manufacturing Co.

CONTROLS, REGULATORS & INSTRUMENTS

Pneumatic Operator **211**

Accurate, high speed positioning and regulating of heavy equipment is provided by a pneumatic positioning operator described in 4-page folder S-15. Cross-section views show construction and supplement the explanation of how the unit works. Republic Flow Meters Co.

Thermometer **212**

Advantages of an industrial thermometer which can be adjusted through a 180 degree angle in any direction are outlined in 4-page folder AA50. Construction features are discussed. Sizes and ranges are listed. Weksler Thermometer Corp.

(Continued on page 131)

20 collector

KIRK AND BLUM
DUST CONTROL SYSTEM

removes 99.5% of dust at FORMICA

A good indication of the efficiency of KIRK & BLUM Dust Control Systems on dust particles of any size is given by a recent installation where small particles are the principle dust load.

At The Formica Company, particle size is in the 100 micron and under range, with 33% of the load under 60 microns. The KIRK & BLUM system installed and illustrated here, serves over 150 machining and micro-sanding operations. The entire system collects approximately 100 pounds per hour. Total loss is less than 8 ounces per hour . . . 99.5% efficient collection.

Such efficiency can save you money . . . whether your production is in wood, plastic or metal . . . because KIRK & BLUM systems are suited exactly to each operation. For details, a survey of your requirements or illustrated literature, please address The Kirk & Blum Mfg. Co., 3174 Forrer Street, Cincinnati 9, Ohio.

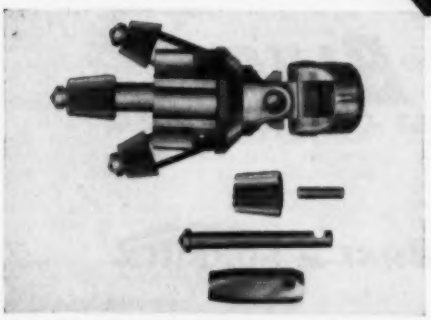
One of many reasons why skilled industrial maintenance workmen prefer

AIRETOOL TUBE CLEANERS

heads that really clean

There's no foreign deposit, in any size tube, straight or curved, that can't be quickly and completely removed by one of the many AIRETOOL tube cleaner heads. Precision made of special heat treated alloy steels, these AIRETOOL heads clean out even the hardest deposits, and restore tubes to their original efficiency. They are constructed with a minimum of parts for easy maintenance, and can be used with a variety of powerful motors for rapid, thorough tube cleaning. The versatility, variety and efficiency of AIRETOOL tube cleaner heads, are basic reasons why they can improve your tube maintenance program. For full details, write to: The AIRETOOL Mfg. Co., 318 S. Center St., Springfield, Ohio.

Wing arm head for cleaning scale, coke, lime or other deposits from curved tubes.



Due to their design and construction, AIRETOOL cleaner heads such as this forwardly swing arm type can be disassembled and put together again without special tools. The arms are designed to reach out to clean every part of the tube wall, and the large number of cutting surfaces insures a quick thorough tube cleaning job.

There's an Airetool Tube Cleaner and Tube Expander for Every Type of Tubular Construction.

AIRETOOL

MANUFACTURING COMPANY

SPRINGFIELD, OHIO

BRANCH OFFICES: Philadelphia • New York • Chicago Tulsa • Baton Rouge • Houston • Hudson Heights (N.J.) REPRESENTATIVES in principal cities in U.S.A., Canada, Mexico, South America, England

There is only

ONE BEST

in

INSULATED PIPING . . .

Ric-wiL

When you have an insulated piping problem, remember that only the best will give you ALL the advantages necessary to full-efficiency performance of your system. That means Ric-wiL Prefabricated Insulated Piping.

Ric-wiL provides (1) top-efficiency system engineering, (2) fast, economical installation, (3) the right protection and insulation for the job.

Ric-wiL PREFABRICATED INSULATED PIPING

UNDERGROUND OR OVERHEAD

THE RIC-WIL COMPANY · CLEVELAND, O.

New bulletins and catalogs

(Continued from page 128)

Control Equipment 213

Equipment for measuring and controlling liquids and gases is the subject of 32-page catalog 003. Units such as controllers, gages, manometers, valves and venturi tubes are described. Principles of operation and specifications are included. Simplex Valve & Meter Co.

FANS & BLOWERS

Centrifugal Blowers 214

Descriptive material on centrifugal blowers, recently added to the list of air moving equipment manufactured by this company, is included in 24-page catalog B-10. Dimension drawings and complete air delivery tables are given for each model. Hartzell Propeller Fan Co.

FILTERS, STRAINERS & PURIFIERS

Purifiers 215

Published to acquaint engineers with facts concerning purifiers, 8-page bulletin 700 discusses units for removal of entrainment in live steam, exhaust steam, vapors and compressed gases. Diagrams illustrate how different types are used to perform various purification problems. V. D. Anderson Co.

HOW TO REQUEST FREE BULLETINS

Insert "key" numbers on return post card found on page 107. Our Reader's Service Department will handle your request promptly

FUELS & FIRING EQUIPMENT

Oil & Gas Burners 216

Advantages of preassembled oil, gas and combination oil and gas burners are listed in 8-page bulletin P-152. The units contain all necessary control equipment, and require only mounting to furnace and service connections. Design features, selection of components and performance are discussed. Units in sizes from 50 to 900 hp are listed for 4 common gas pressures and all grades of oil. Coen Co.

Oil Booster 217

Advantages of oil boosters, for heating oils, bituminous or heavy viscous materials, are the subject of 4-page folder AD-108. Units are available with burners for light or heavy oil, or gas. Specifications and typical installations are presented. Road Machinery Div., Cleaver-Brooks Co.

LUBRICANTS, LUBRICATION, OIL FILTERS & PURIFIERS

Lubricant 218

High load-carrying ability, non-corrosive qualities and longer lubricating life are advantages listed for an extreme-pressure lubricant described in 12-page booklet A-2612. The new lubricant, developed primarily for high-output industrial gearing, is also recommended for heavily loaded plain bearings and screws. Lubricating problems caused by stepping up pro-

(Continued on page 132)

Reliability
DESIGNS THAT REPRESENT 50 YEARS TRAP BUILDING EXPERIENCE
"airxpel"
STEAM TRAPS
Remove Both Air and Condensate
This equipment offers design advantages that represent long experience in building steam saving devices for industry.
Orifices of Wright-Austin traps can be interchanged without disassembling the trap. Connections are the straight-through type. Both of these features contribute to speed and ease of installation.
Wright-Austin traps are available for lines ½" to 3", for pressures up to 600 P.S.I.G. and with capacities up to 65,025 pounds of water per hour.
For complete information on traps and other accessories that you can stock to advantage and depend on for efficiency that means low cost, write, today, for:
Trap Catalog #600
Separator Catalog #500
Boiler Trim Catalog #700
"CUB" TYPE ½" to 1½" to 250 PSIG
"MASTER" TYPE ½" to 2" to 300 PSIG
"Y" STRAINERS 2" to 8" (flanged) ½" to 3" (threaded)
FORGED STEEL ½" to 1¼" to 600 PSIG
WRIGHT-AUSTIN
STEAM TRAPS
WA Standard
STEAM USERS SINCE '94
WRIGHT-AUSTIN
COMPANY
3245 WIGHT STREET • DETROIT 7, MICH.

New bulletins and catalogs

(Continued from page 131)

duction with existing equipment are outlined, together with recommendations. Sun Oil Co.

Graphite Lubricant **219**

Advantages of colloidal graphite as a high-temperature lubricant are outlined in 4-page folder 423. How it is used and recommendations for specific lubrication problems are given, together with case studies. Acheson Colloids Co.

Lubricators **220**

Force feed lubricators for all types of machinery are described in 16-page catalog L-52. Details of design and construction, as well as specifications, are presented for open and enclosed types with capacities from 2 to 32 pints with 1 to 24 feeds per unit. Hills-McCanna Co.

REFRACTORIES

Insulated Walls **221**

Thin wall construction for industrial furnace enclosures is described in a 12-page bulletin. Photos and engineering drawings show the thin, insulated walls as used for boilers, refinery heaters, dryer furnaces and kilns. Bigelow-Liptak Corp.

Water Wall Tile **222**

Thin refractory tile construction for water wall backing and boiler baffles is described in 8-page bulletin 44. Engineering information shows how tile are installed and presents charts and graphs of heat losses and physical characteristics. Recommendations for the design of tie backs also are given. Laclede-Christy Co.

PACKINGS & GASKETS

Mechanical Packing **223**

Included in 20-page catalog PC-102 is an application chart which provides a quick and accurate means of determining the proper packing for a specific service condition. Data, structure and performance of self-lubricating, molded, sheet and Teflon packings are presented. Greene, Tweed & Co.

MOTORS & GENERATORS

Totally-Enclosed Motors **224**

Totally-enclosed and explosion proof motors, safe for dangerous, damp and dusty locations, are the subject of 8-page brochure F1784. Design features, advantages and applications are described. Actual installations are shown. U. S. Electrical Motors, Inc.

Motor Selector **225**

Detailed information on EMC and Cyclohm fractional motors in ratings from 1/2000 to ½ hp is provided by a slide rule selector. It is said to provide all data necessary for determining which motor will best meet any given set of requirements. Howard Industries, Inc.

DIESELS

Diesel Engine **226**

Smaller and lighter, but for heavy-duty service, is the description of a diesel engine discussed in 12-page bulletin 10027. Three models are listed, ranging from 200 to 380 hp at 900 to 1000 rpm. Specifications, weights, performance curves and dimensions are included. Ingersoll-Rand Co.

ELECTRICAL HEATING UNITS

Electric Comfort Heaters **227**

Listed in 8-page catalog D-52 are 75 different models of forced air, convection and radiant heaters in capacities of ¼ to 100 kw. Information is presented to aid in selecting the proper unit for any particular job. A quick selector chart shows how to calculate heat requirements for given areas and types of building construction. Edwin L. Wiegand Co.

HEAT EXCHANGER EQUIPMENT

Heat Exchangers **228**

Various types of heat transfer equipment are among the products described in 12-page catalog 12. Also presented are various types of dry blending equipment and such process equipment as kettles, evaporators, vessels, reactors and coils. Specifications are included. The Patterson-Kelley Co., Inc.

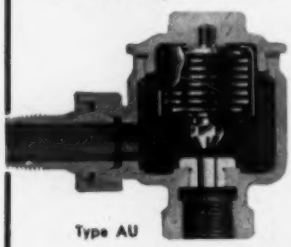
Nicholson Makes

FREEZE-PROOF STEAM TRAPS for Every Plant Use

Because they drain completely when cold, these four types of Nicholson steam traps are positively freeze-proof. Can be freely installed outdoors. Universally recommended for use in lines which need not be in continuous use during cold weather, because they are freeze-proof and because their 2 to 6 times average drainage capacity results in minimum heat-up time. The non-air-binding feature of Nicholson traps also notably facilitates steam transfer in severe weather.

TYPES FOR EVERY PLANT USE—process, heat, power; size ¼" to 2"; pressures to 250 lbs.

Catalog 751 or see Sweet's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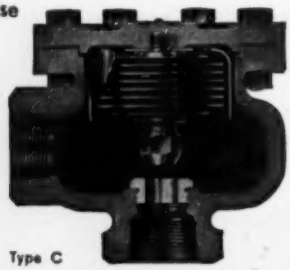
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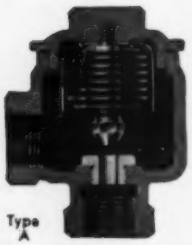
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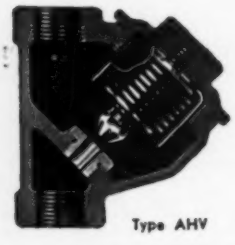
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Condensers 229

Described in 4-page folder 800 are condenser-heater-cooler units recently developed to meet the demand for low cost, junior size heat exchangers. Three types are described—coil, straight tube and pipe line. A wide range of construction materials are available for resistance to most liquids and chemicals. Manning & Lewis Engineering Co.

STEAM SPECIALTIES

Impulse Steam Traps 230

Construction and advantages of high capacity impulse steam traps are described in 4-page folder T-1745. Units are listed for maximum continuous discharge up to 37,400 lb per hr of condensate. Dimensions and materials of construction also are presented. Yarnall-Waring Co.

Industrial Steam Trap 231

Features of construction and operation of small size industrial steam traps, from ¼ to ¾ in., are given in data sheet 351. Applications are suggested. Tables list dimensions and capacities at various pressures. W. H. Nicholson & Co.

HOW TO REQUEST FREE BULLETINS

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Compound Steam Traps 232

Piston-operated compound steam traps for draining equipment producing large amounts of condensate, such as purifiers, separators, evaporators, and desuperheaters, are discussed in 8-page bulletin 215. In addition to describing the construction and listing physical data, such details as how they work, operation and installation are covered. Armstrong Machine Works.

THERMAL INSULATION

Fire-Retardant Mastics 233

Fire-retardant mastics for use in conjunction with thermal insulation to reduce the fire hazard of exploding gas and eliminate the need to bury tanks, is described in a data sheet. The product, for trowel or rubber-glove application, is described as providing good heat resistance over insulated pipes, vessels and equipment. A typical specification indicates how it is used. Benjamin Foster Co.

PIPE, TUBING & HOSE

Air Hose 234

Five grades of air hose, described as having tough, oilproof covers to prevent peeling, are featured in 4-page folder 3460. In addition to listing specifications, materials and methods used in construction are described together with recommended uses for the various types. B. F. Goodrich Chemical Co.

Plastic Pipe Data 235

Data on head loss due to friction in plastic pipe are given in the form of charts and graphs. A graph of water flow vs. head loss for both plastic and steel pipe gives a comparison of flow characteristics. Carlon Products Corp.

Pulsation Dampener 236

Described in 4-page folder PDS-8501 are pulsation dampening piping systems designed for any type gaseous stream at operating pressures from vacuum to 5000

(Continued on page 134)

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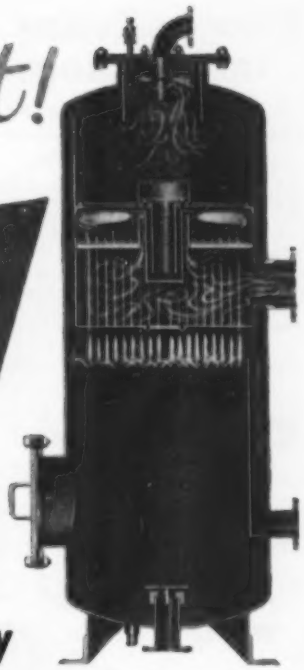

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New bulletins and catalogs

(Continued from page 133)

psi and at any temperature. Advantages and principles of operation are discussed. The Fluor Corp., Ltd.

Expansion Joints **237**

Basic designs of corrugated expansion joints are described in 20-page brochure CMH-127R. A table of thermal expansion, together with discussions of design considerations, tables of axial and lateral motion, descriptions of construction materials, diagrams of typical installations and installation data, is presented to aid engineers in proper selection and application. Specifications for many types are tabulated. Flexonics Corp.

Insulated Piping **238**

Prefabricated, insulated piping systems, for underground piping of steam, hot water, oil, process liquids and gases, are the subject of 4-page folder 5205. Advantages, construction, applications, types of joints and typical installations are discussed. Also presented are prefabricated tunnel systems, manholes and sectional conduit systems for protection of underground insulated piping. The Ric-wiL Co.

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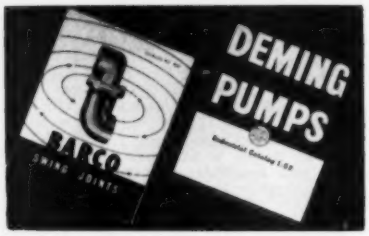
Swing Joints **239**

Ball bearing equipped swing joints for use on lines handling oil, gasoline, chemicals and other liquids are described in 8-page brochure 400. Construction features, specifications and dimensions are presented. Other products such as ball, revolving and swivel joints also are listed. Barco Manufacturing Co.



PUMPS

Industrial Pumps **240**

Included in 96-page catalog I-52 are descriptions of a wide variety of industrial pumps. Among the basic types represented are many models of centrifugal, vertical turbine, rotary, piston and reciprocating units. Selection tables and data of interest to pump users are presented. An illustrated table of contents provides a means of quick reference. The Deming Co.

Vertical Pumps **241**

"Vertical Pumps for Volatile Fluids," 6-page folder 1026, describes the advantages of vertical turbine pumps for handling such liquids as gasoline, diesel fuel, crude oil, L-P gases, and ammonia. The mechanical features of several models are shown. Efficiency curves are included in the engineering data. Johnston Pump Co.

Process Pumps **242**

Rubber lined centrifugal chemical and process pumps, designed especially for handling strong acids and corrosive salts, are the subject of 4-page folder WQ-212. Service characteristics, construction, advantages and specifications are presented. Capacities are listed to 2000 gpm with heads to 125 ft. Warren Steam Pump Co., Inc.

Vertical Pumps **243**

Construction features of small vertical pumps for sidewall or submerged mounting are described in 8-page bulletin 52B-6975A. Units are listed in capacities to 250 gpm at heads to 125 ft for such service as coolant circulating and air conditioning. Data for determining motor frame, horsepower, speed and current characteristics are included. Allis-Chalmers Co.

Centrifugal Pumps **244**

Descriptions and typical applications of many types of self-priming and straight centrifugal pumps are presented in 4-page reference bulletin G-52. Also described are diaphragm and plunger sludge pumps. Marlow Pumps.

WATER TREATMENT

Distilling Plants **245**

Industrial applications for vertical basket type sea water distilling plants are suggested in an 8-page bulletin. Types of evaporators are discussed, together with such topics as the problem of scale, simplicity of operation and purity of the final product. Flow charts and diagrams are presented. The Maxim Silencer Co.

Marine Demineralizers **246**

Technical bulletin sheet 015 describes a demineralizer designed specifically for use on such marine vessels as barges, ferries and tugs. In addition to a discussion of

advantages, a description of the construction and a table of specifications are given. Penfield Manufacturing Co., Inc.

TRANSFORMERS

Instrument Transformers **247**

"Instrument - Transformer Accuracy Standards," 16-page bulletin GET-1366A, is published to facilitate selection of proper instrument transformers for any particular application. The booklet lists accuracy standards for potential, metering current and relaying current types. Diagrams show graphical equivalents of American Standards Association accuracy classes. General Electric Co.

VALVES

Check Valves **248**

Stop, check and non-return valves are the subject of 16-page catalog 12-H. Descriptions, design features, construction, specifications and dimensions for each type, in sizes from 2½ to 14 in. and in 600, 900, 1500 and 2500 lb pressure classes, are presented. Edward Valves, Inc.

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MISCELLANEOUS

Metal Recovery **249**

One of the fields in which ion exchange holds great promise is in the recovery of valuable metals from dilute solutions resulting from various manufacturing processes. Information on the subject is contained in a 9-page reprint 3737-7, "Metal Recovery by Ion Exchange." Tables, charts and other data illustrate some of the forms in which metals are present in solutions, and tell how they could be economically recovered. The Permutit Co.

Reviews of EXTERNAL HOUSE ORGANS

For a regular copy of a particular house organ, write direct to company

Armstrong Trap Magazine

"How to Figure the Costs of Steam Traps" an article in Vol. 21, No. 5-1952, is an example of the useful articles contained in this 16-page publication. Information on valves, humidifiers, and other steam specialties, as well as steam traps, is presented in an interesting manner. Other articles included in this issue are entitled: "Did You Ever Auscultate a Steam Trap?"; "Right Trap Cuts Cooking Time 40%"; "Case of the Banging Radiators"; and "New Forged Steel Ball Float Trap." Armstrong Machine Works, Three Rivers, Mich.

Maintenance News

Engineers concerned with electrical equipment maintenance will find information of value in a house organ devoted exclusively to the problems of keeping equipment in shape. A recent issue, Vol. XVIII, No. 3, 12 pages, includes such articles as: "Insulating Practices for the Electrical Repair Shop"; "Select Couplings to Fit the Job"; "Four Ways to Make Your Maintenance Stockroom Pay"; "Preventive Maintenance"; and "Repairing Weld Leaks in Power Transformers." Westinghouse Electric Corp., East Pittsburgh, Pa.

—*End*

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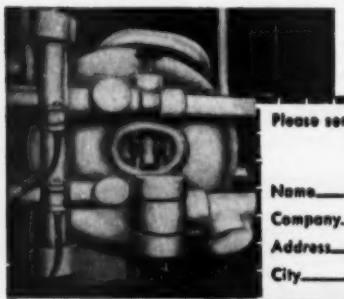

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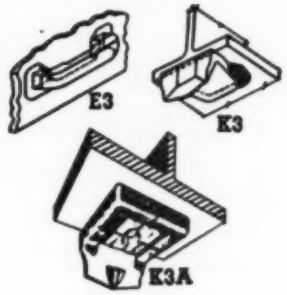

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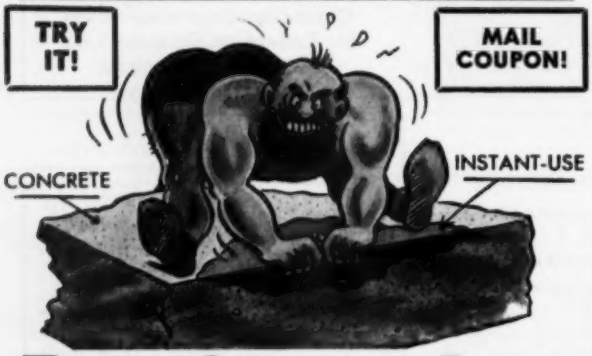

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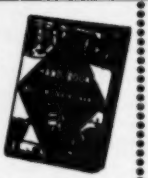

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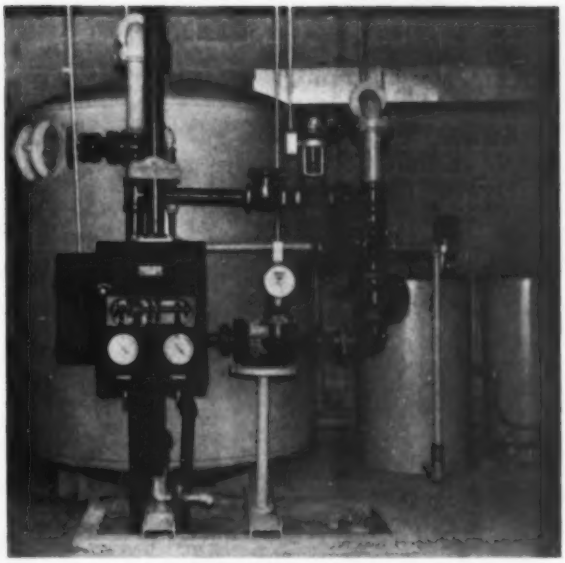

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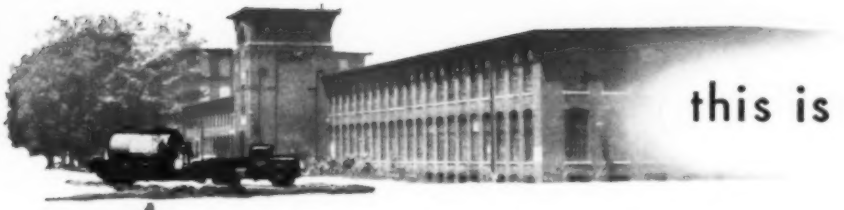

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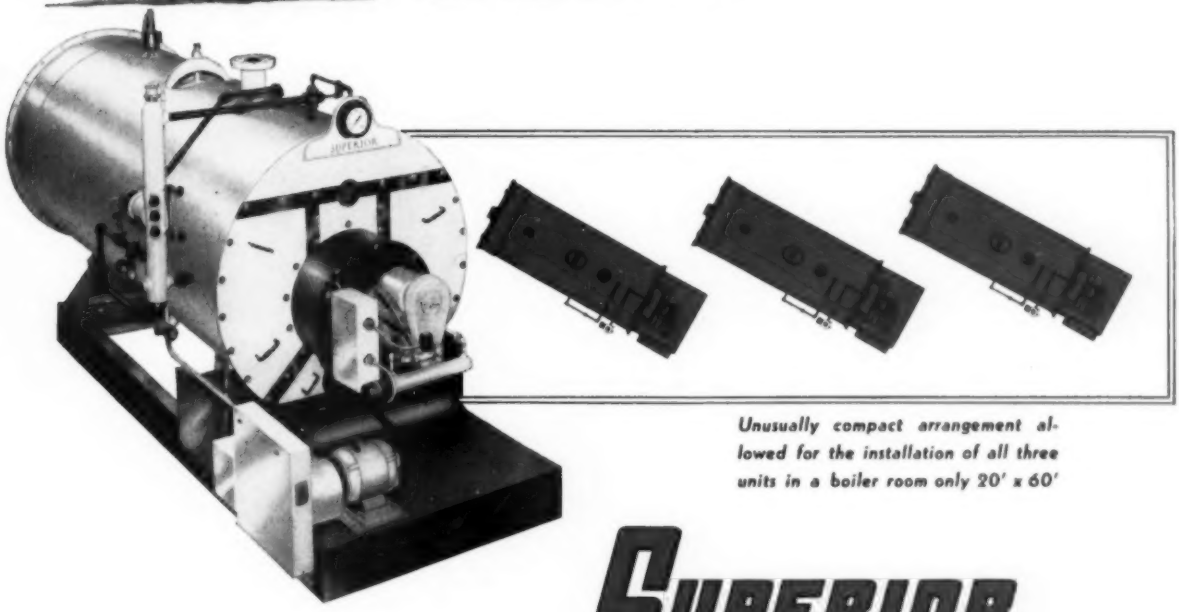

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